AMERICAN JOURNAL OF ORTHODONTICS

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OFFICIAL PUBLICATION OF
THE AMERICAN ASSOCIATION OF ORTHODONTISTS,
ITS COMPONENT SOCIETIES, AND
THE AMERICAN BOARD OF ORTHODONTICS

PUBLISHED BY THE C. V. MOSBY COMPANY, ST. LOUIS 3, U. S. A.

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Vol. 40, No. 8, August, 1954. American Journal of Orthodontics is published monthly by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription price: United States and its possessions, $10.00; Canada, $10.25; Foreign, $11.00. Entered as Second-class matter, January 14, 1915, at the Post Office at St. Louis, Missouri, under the Act of March 3, 1879. Printed in the U. S. A.

American Journal of ORTHODONTICS

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VOL. 40 | AUGUST, 1954 | No. 8

Original Articles

A CRITICAL REVIEW OF CEPHALOMETRICS

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THE practice of orthodontics as a specialty is comparatively new, and the first exclusive practitioners appeared around 1900. They were mostly the graduates of the Angle School of Orthodontia, and they represented the first group of orthodontic specialists. Since that time, the number of those who have devoted their entire time to this phase of dentistry has increased, and today we are training the third generation of exclusive practitioners in ever-growing numbers.

While orthodontics was practiced much before Dr. Angle's time, orthodontists gained professional recognition only after the appearance of the exclusive specialists. Because of their loyalty to Dr. Angle and their unlimited sincerity and enthusiasm, they earned the respect of the entire dental profession. Through their untiring efforts and the results they have obtained, they firmly established orthodontics as a specialty. In addition to taking care of private practices, these men have engaged in research and they have begun to investigate the different phases of orthodontics. As a result of these efforts, the science and art of orthodontics expended very rapidly and today we have sufficient new material contributed by individuals and groups of investigators to support a monthly journal devoted exclusively to orthodontics.

The material published in the AMERICAN JOURNAL OF ORTHODONTICS covers every phase of the specialty, and the contributions are so numerous that they create a confusion, especially in the minds of the younger men. There is no agreement on many points, and the controversies naturally arising from the disagreements tend to further accentuate the confusion. Among the subjects covered are appliances, etiology, growth and development, measurement of growth changes, relationship of the dentition to the rest of the head, diagnosis,

Read before the Central Association of Orthodontists in Chicago, Ill., Oct. 19 and 20, 1953.

extraction, and numerous other factors with which we are not concerned at present.

The study of the present status of these different phases of orthodontics reveals that investigations follow certain trends. These trends have been so well established that they influence our way of thinking and our methods of approach to orthodontic problems. Our thinking follows a well-defined pattern and proceeds along previously accepted lines. Changes from these established patterns are subconsciously resisted and this gives rise to differences of opinions and sharp disagreements. There can be no doubt that these disagreements are sincere; therefore, it is not surprising to find that, once these opinions are formed, they are strongly adhered to. It is of great importance to mention here that it is most difficult to reorient the thinking of a recent diplomate of a post-graduate course in orthodontics. He has been trained to think along firmly established lines, and he does not possess sufficient knowledge and experience to think and act independently, and venture to deviate from the accepted methods of procedure. It is equally true that the more experienced older practitioners also resist a change in their approach to orthodontic problems, but this is caused mainly by inertia and by an unwillingness to change from one method of treatment to another, which always involves additional effort. It requires two years of work to transform a practice using labiolingual technique to the use of the edgewise arch appliances. Disagreements exist in every department of orthodontics. There are those who prefer to treat their cases by the labiolingual technique, while others may prefer the Johnson, the edgewise, or the modified edgewise arch appliances. Some also believe that a reliable diagnosis can be made only by the use of cephalometric radiographs and on oriented models, while others attach no special importance to cephalometric records.

Regardless of the foregoing differences, the advance in the science and art of orthodontics was nothing short of phenomenal. In the development of our young specialty, imagination played an important role and, despite frequent disagreements, the advance was very rapid. The use of imagination is a necessary requirement for the advancement of science, and Brash[1] very appropriately stated in his book, *The Aetiology of Irregularity and Malocclusion of the Teeth:* "Science proceeds by the controlled use of the imagination applied to preliminary data, whereby provisional hypotheses are formed; such provisional hypotheses may be of enormous value as guides to investigation, even though they may subsequently prove to be inadequate or false." In some phases of the broad orthodontics problem, our imagination was hardly applied, while in connection with other phases our imagination carried us away; thus, many of us became slaves to the conditions created by such uncontrolled imagination.

We have made very creditable advances in orthodontic appliances. The early mechanical devices were not very efficient, for they depended upon the characteristic tendencies of the teeth to move into normal positions. This did not suffice in many instances, however, and more definite appliances had to be devised to bring about the more difficult kinds of tooth movements. Thus, the simple labial arch appliance was slowly replaced by multibanded appliances and

through the pin and tube and ribbon arches, the edgewise arch mechanism was developed, which represents the ultimate in appliance design. Concurrently, the modified edgewise appliance with the split tube and lock, and swirl tubes as accessories, and also the Johnson twin arch were adapted to general use. In addition to these working appliances, other accessories were used with more or less satisfaction to change the occlusal level and to drive the maxillary teeth distally en masse. In this department, our imagination produced excellent results and it seemed for a while that the orthodontics problem was wholly mechanical.

It was not very long before we found that mechanical treatment represented only a small part of the orthodontist's problems. Many questions arose and it became necessary to give explanations to these questions. Inasmuch as we are always dealing with malocclusions, which are primarily deformities of the jawbones and not of the dentition, the first question which asserts itself is, What is a malocclusion? Angle defined malocclusion of the teeth as "the perversion of their normal relations." This implies that normal occlusion of the teeth, or their normal relations, has already been defined and that the concept of normal occlusion is permanently fixed. The recognition of the malocclusion, therefore, of necessity must be a comparison with the normal occlusion, and it represents a deviation from the normal. This deviation, however, is a deviation from a theoretically fixed position of the teeth and it never represents a malformation of the teeth, which nearly always are formed normally. In order to make both a qualitative and a quantitative comparison, we must be able to relate the malocclusion to the normal occlusion in such a manner that the magnitude and direction of the deviation are accurately recorded. The required correction always will be equal in amount and opposite in direction to the deviation from the normal. To be able to do this, however, requires additional information, and it becomes important to know how growth takes place and how a growing part may be affected unfavorably during growth. Without this knowledge, it is not possible to relate a growing part or a part undergoing orthodontic change to its future form of increased dimensions. It is imperative that we know the actual mode of enlargement and the influence of injurious agents on a growing part. We are not certain that general injurious agents can affect a growing part unfavorably, but there is sufficient evidence to suggest that this may actually occur. Any attempt to relate a growing part at an earlier stage to its form at a later stage must take into account, in addition to actual form and measurements, the mode of enlargement and the possible influence of general injurious agents. The available information regarding growth is insufficient to enable us to compare properly several stages of any part of a growing individual.

The effect of nocive influences on the development of the jawbones and the dentition is closely connected with the study of the etiology of malocclusion. Obviously, the injurious agents capable of retarding or augmenting growth represent the etiological factors, whether they are local or general in character.

There was little imagination applied in the study of the etiology of malocclusion. Our knowledge relating to this phase of orthodontics has remained static for the past fifty years. In the seventh edition of Dewy's ***Practical***

Orthodontics,[2] which recently was revised by George M. Anderson, there was nothing new to report in the chapter on etiology. While it is true that the etiological factors are classified as inherited, congenital, and acquired, no attempt was made to differentiate between inherited and acquired conditions, which admittedly may have similar characteristics. If some malocclusions of the same type are inherited and others are acquired, then it becomes necessary for us to know whether there are other symptoms associated with the acquired malocclusion which would enable us to differentiate it from the inherited type. In other words, if a growing individual is subjected to general injurious influences of sufficient intensity to effect the growth of the jaws, then all the other bones in the body must show recognizable signs of injury, the extent of which may vary in the different locations. It seems that this particular point has been entirely overlooked by our investigators, and attention is focused on a few well-known conditions with congenital causes and a large group of conditions which are unquestionably acquired. These acquired conditions are caused by the early loss of deciduous teeth, tardy eruption of the permanent teeth, early loss of the permanent teeth, improper restorations, loss of mesiodistal diameter, prolonged retention of the deciduous teeth, disorderly eruption of the permanent teeth, transposed teeth, nest of miniature or supernumerary teeth, deflected canines, lack of spacing, habits, accidents, mouth breathing, enlarged tonsils, nasal sinus pathology, and abnormal muscular activity, including both extra- and intraoral pressure habits.

These causes are all local in character and there can be no question that they may produce characteristic dentofacial deformities. It is to be noted that there is a definite link between cause and effect, and a particular condition can be directly traced to a corresponding cause, but it is not made sufficiently clear that an inherited condition may be normal or abnormal. Both the normal occlusion and the malocclusion thus inherited may be affected by constitutional disturbances, changing the normal occlusion into malocclusion, and altering the character of the inherited malocclusion. In addition, all these different conditions may be acted upon by any or all of the previously enumerated local factors. While mention is made of the inherited conditions, and the possible influence of constitutional disturbances, our textbooks do not indicate just what the relationship may be between these etiological factors, and our understanding of the real etiological problem remains extremely limited.

In a series of four lectures delivered by Brash in 1929 at the Dental Hospital of Edinburgh, the University of Birmingham, and the Royal Dental Hospital of London, the problem of the etiology of malocclusion was fully discussed. It was pointed out that "most of the conclusions at which we have now arrived seem to be negative, yet it must be admitted that the data are so incomplete that many of them cannot be taken as final." To indicate how little is known of the real etiological factors at present, Brash further relates the following:

> When I first began for my own information to compile a list of supposed causes of irregularity and malocclusion of the teeth, I was reminded of a lecture I once heard by the late Dr. Strangeways on "Rheumatoid Arthritis" and of the way in which he illustrated at

once and at the same time our ignorance of the aetiology of the joint affections and the inherent craving of the human mind for explanations, by displaying a long list of alleged causes ranging from "heredity" to "tight collars." Malocclusion, however, has the advantage over rheumatoid arthritis in another respect, in that while Strangeways was able to display another equally long list of proposed treatments or alleged cures, ranging between the extremes of golf and prayer, a corresponding list would find, beyond technical operations of mechanical regulation, little to include save perhaps the removal of adenoids, and the possible addition by some enthusiasts of muscle exercises for the face.

These words were written more than twenty years ago, and since that time our understanding of the etiological problem has not changed. While the removal of third molars, four premolars, tonsils, and the labial frenum are freely recommended, with our present knowledge we have no right to subject our patients to these operations. It is imperative that we, as a profession, pay more attention to this phase of orthodontics and apply our imagination for the solution of this perplexing problem. A better knowledge of the etiology will not help us in the treatment of orthodontic cases. Primarily, it will become the basis of preventive orthodontics, for if we know how deformities are formed, we may also prevent them. It also will help us in deciding the probable outcome of those patients who will undergo orthodontic treatment. At this time we suspect that the prognosis of acquired cases is better than that of the inherited types. This may or may not be true, but it would be desirable to know one way or the other.

The study of the causes of malocclusion deals with those factors which initiate the formation of deformities. How the deformities are formed under the influence of etiological factors is a subject of separate study, which deals with growth and development and also with changes in growth under the influence of injurious agents. Nothing definite is known regarding these changes, and it has not been established that general constitutional causes have any effect at all on a growing body; but the following illustrations (Fig. 1) by T. Wingate Todd would suggest that systemic causes may have a far-reaching influence. In his paper on "The Orthodontic Value of Research and Observation in Developmental Growth of the Face," which appeared in the *Angle Orthodontist*,[3] he said:

We are so accustomed to think of exact details of facial form and even of the occlusal pattern of the dentition as being determined by heredity, that we know practically nothing of the environmental effects upon facial form and all too little of their influence upon occlusal pattern. Nevertheless, our faith is justly strong in our power to modify both these characters by suitable treatment. What we can do, nature is undoubtedly doing and there is just the possibility that we may, in our eagerness, confuse nature's handiwork with our own.

I propose to present two skulls in contrast in order to illustrate this thesis. One is the skull of a healthy white baby of four months (W. R. U. 818) who died from an intussusception; the other that of a female white infant of nine months (W. R. U. 1801), the victim of decomposition. She had a birth weight of three pounds and was supposed to be a six-months baby. The father deserted and the child was put into a boarding home for six weeks. During this time she was ill with cough and fever. When brought to the hospital she was acutely ill with bronchitis, then broncho-pneumonia, subcutaneous abscesses, otitis media and decomposition. The skeleton after death showed that development had been arrested at three months. The difference in sex is of no particular consequence in this study which deals with facial development, not with size.

The two crania are about the same size. Indeed, the younger child has a somewhat larger brain case. No. 818, the younger skull, has a cranial capacity of 797 c.c. and No. 1801, the older, 700 c.c. Comparison of the illustrations shows differences in the form of cranial growth which may be hereditary, but may also be environmental in origin.

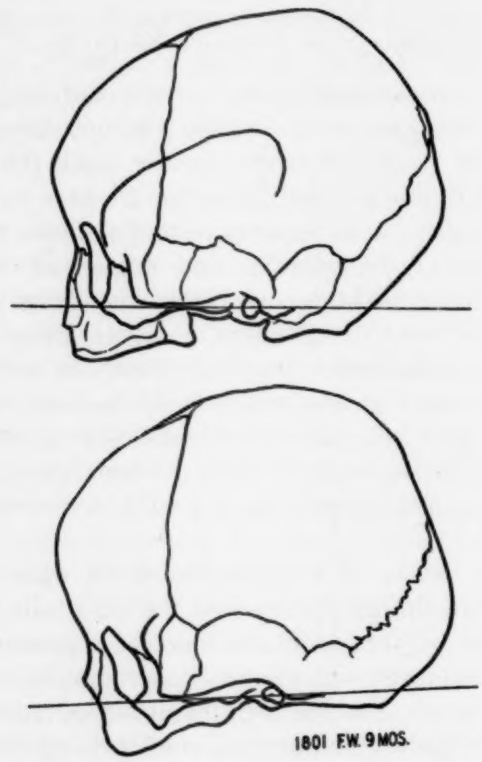

Fig. 1.—(From Todd: *Angle Orthodontist* 1: 67, 1931.)

The striking distinction is in the face. Set up in the Franfort plane, the underdevelopment of the face in No. 1801 compared with No. 818 is obvious in the oblique slope of the vertical axis of the orbit. In No. 1801, owing to failure of forward growth of the lower face, it does not keep pace with forward growth of brain case. It is also plain that defective growth is focused particularly upon the naso-pharynx which is far less roomy than in No. 818.

Anyone is at liberty to question the relative significance of heredity and of disease in bringing about these distinct facial contours, but no one would deny that disease does not have some detrimental effect upon growth and development.

If we provisionally accept, on the strength of the foregoing evidence, that growth can be altered under the influence of a general injurious agent, then we must seek an explanation of growth itself. When we speak of growth and development, we understand that growth is merely an enlargement, while development is the unfolding of the individual. Growth and development take place simultaneously, so that the young individual is gradually molded into his predetermined form. However, growth is not a simple process and it is important for us to know how it takes place in order to be able to understand the alteration of the normal processes under the influence of systemic disturb-

ances. A study of growth will reveal that enlargement takes place as a result of surface deposition and absorption of bone, which is always accompanied by interstitial changes. As a general rule, deposition takes place on the outer surfaces and absorption on the inner surfaces of the growing part, but, this is not always true and the mandible and the maxillae are exceptions to this rule. If we studied the growth of a long bone such as the femur and traced it through its entire growth period from infancy to adulthood, we should see a great change in size from the bone of the infant to that of the adult. The bone of the infant is much smaller in size. In Fig. 2 this difference in size is shown in *A*, where the infant femur is laid alongside the adult bone. It is an accepted procedure to compare photographs, radiographs, or diagrams of growing parts at different periods of development. This method of comparison, however, may lead us to unwarranted conclusions. The only observation which may be made from the conditions depicted in *A* is that the adult bone is larger than the bone of the infant, and any other inference beyond that is unwarranted and is not acceptable. The relationship shown in *B* is much more specific, which clearly shows the difference in size together with the direction and the amount of growth necessary to transform the infant bone into a fully developed adult bone. It should be taken into account also that the bone of the child is completely resorbed during growth and it forms no part of the completed femur; in other words, the bone of the child is only transitional and nothing of it remains when the bone is completely formed. We are accustomed to thinking of growth as the result of surface deposition and too often forget that resorption is also a very important process of growth. This is true of every bone in the body; the mandible and maxillae are no exceptions. The diagrammatic representation in *B* carries with it the tacit assumption that the point of registration is known and serves conclusively in comparing the outlines of a growing bone at different stages of development. This assumption is accepted without further inquiry, and thus, unwittingly, we accept all the faulty conclusions that may be suggested by such representations. The registration in *C* depicts a condition where the major part of growth takes place at the lower end of the infant femur, while the diagram at *D* forces the conclusion that most of the growth occurs at the upper end of the developing bone. While the most probable relationship of the two stages of development is more nearly represented at *B*, none of these registrations are acceptable, and we must always guard against unwarranted conclusions. The most common error is made when the growth of two or more bones is studied from one single registration point. In the last two columns of Fig. 2, the femur and the tibia are diagrammatically represented while standing and when the lower extremity is flexed. The adult bones are shown by heavy solid lines while the infant bones are drawn in heavy broken lines. If we confine our attention to the relationship of the bones in the "standing" position, we will note that when the femurs of the adult and the infant are registered according to the conditions shown in *B*, *C*, and *D*, the relative positions of the tibias at different levels of development do not register in a similar manner. We may conclude that this difference in position represents growth, but that conclusion would violate the method of enlargement we have accepted for the femur,

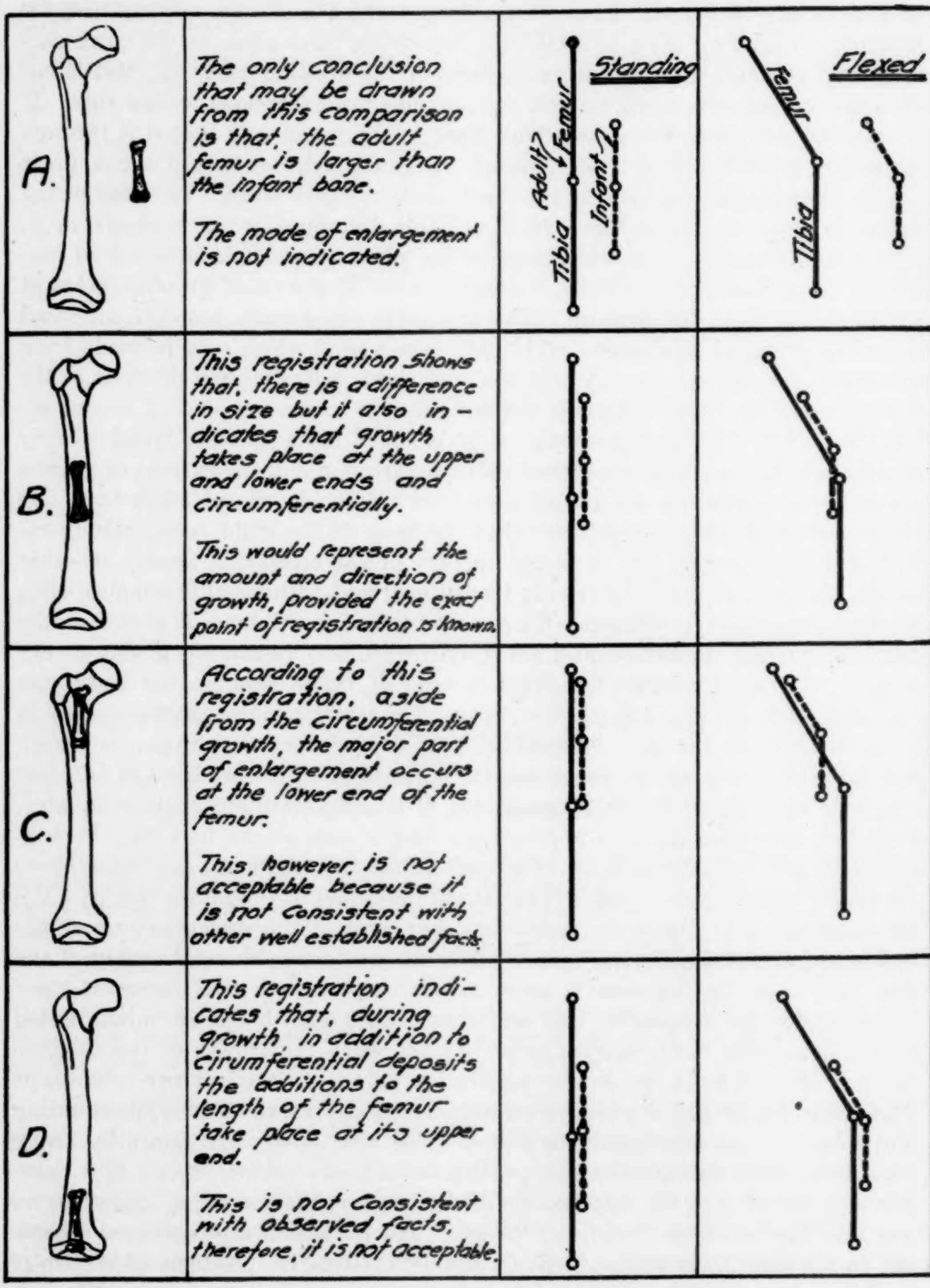
A.
The only conclusion that may be drawn from this comparison is that the adult femur is larger than the infant bone.
The mode of enlargement is not indicated.
Standing
Adult Femur
Tibia
Infant 2
Flexed
Femur
Tibia
B.
This registration shows that there is a difference in size but it also indicates that growth takes place at the upper and lower ends and circumferentially.
This would represent the amount and direction of growth, provided the exact point of registration is known.
C.
According to this registration, aside from the circumferential growth, the major part of enlargement occurs at the lower end of the femur.
This, however, is not acceptable because it is not consistent with other well established facts.
D.
This registration indicates that, during growth, in addition to cirumferential deposits the additions to the length of the femur take place at its upper end.
This is not consistent with observed facts, therefore, it is not acceptable.

Fig. 2.

as to whether it is in accordance with the conditions shown in *A, B,* or *C.* Now it is clear that it cannot be admitted that different bones of the same kind become larger in a different manner. It is unthinkable that a bone like the tibia grows in a different manner than another long bone such as the femur. Yet, these representations imply a different mode of enlargement for the tibia, and, as it will be shown later, in the use of cephalometric radiographs we draw very similar conclusions. In the last column of Fig. 2, these relationships are shown more clearly and, when the lower extremity is flexed at the knee, the difference in the positions of the infant and adult tibias cannot represent growth. It is also very important to keep in mind that the infant bone is completely resorbed during growth and does not form an integral part of the adult bone. This is true of every bone in the skeleton.

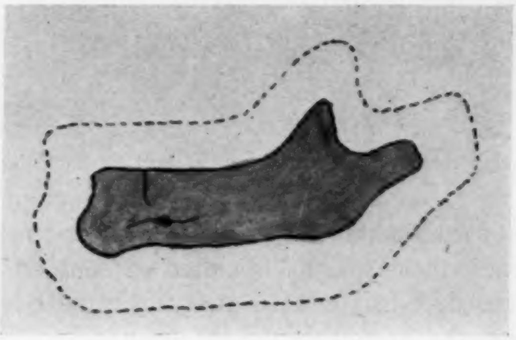

Fig. 3.

A similar problem arises in connection with the growth of the mandible. This is a more complex change, and Fig. 3 clearly shows that if we apply the rule of "deposits on the outer surfaces," it will not be possible to account for all changes. The mandible would develop into a larger bone retaining the characteristics of the infant mandible. Evidently, trying to fit the infant mandible into the adult bone, so that even deposits are represented on all outer surfaces, is not the correct way of relating these outlines to each other. This was called to our attention very long ago by John Hunter (Fig. 4), and the following is his description of the growth of the mandible from birth onward:

The jaw still increases in all points till twelve months after birth, when the bodies of all the six teeth are pretty well formed, but it never after increases in length between the symphisis and the sixth tooth; and from this time too, the alveolar process which makes the anterior part of the arches of both jaws, never becomes a section of a larger circle, whence the lower part of a child's face is flatter or not so projecting forwards as in the adult.

After this time, the jaws lengthen only their posterior ends, so that the sixth tooth, which was under the coronoid process in the lower jaw and in the tubercle in the upper jaw of the foetus is at last—viz., in the eighth or ninth year—placed between these parts, and then the seventh tooth appears in the place which the sixth occupied with respect to the coronoid process and tubercle, and about the twelfth and fourteenth year, the eighth tooth is situated where the seventh tooth was placed. At the age of 18 or 20, the eighth

tooth is found between the coronoid process in the lower jaw, and under or somewhat before the tubercle in the upper jaw, which tubercle is no more than a succession of sockets for the teeth until they are completely formed.

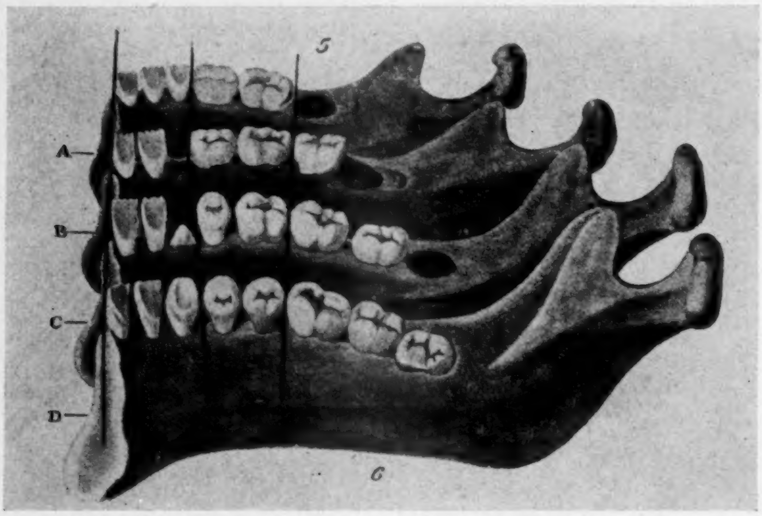

Fig. 4.—(From Wallace: Variations in the Form of the Jaws, William Wood & Company, publisher.)

Fig. 5 represents diagrammatically Hunter's description of the enlargement of the mandible, which was the accepted explanation for more than 200 years. Hunter advanced the hypothesis that about twelve months after birth the anterior part of the mandible, more specifically the part "from the symphisis to the sixth tooth," never increases in length. In accordance with this hypothesis, he used the median contact point between the mandibular central incisors as a point of registration in relating mandibles of different ages to each other.

In his article, "Growth of the Jaws and Palate," which appeared in the *British Dental Journal,*[4] Brash reported the results of his experiments on madder-fed pigs. He conclusively showed that the part of the mandible included between the symphysis and the first permanent molars is not static, and that in the anterior part of the dental arch the teeth move forward through the bone during growth. This forward movement is accompanied by resorption in front of the moving teeth and deposition of bone behind them. Brash also showed that the lingual surface of the mandible is slowly resorbed during growth and that there is a heavy deposit on all outer surfaces. This leads to the conclusion that during enlargement the infant jawbones are completely resorbed and they do not form part of the adult jaws. The 200-year-old explanation of Hunter is thus shown to be at variance with the exhaustive and accurate experimental findings of Brash. Fig. 6 more nearly represents the mode of increase in the size of the mandible. If we accept Brash's findings, then we lose the registration point and we can indicate only the site and direction of bone deposition and absorption during growth.

A much greater difficulty exists in the study of the growth of the maxillae. According to the analogy drawn by Hellman, the "maxilla grows from before

backwards." He assumed that there is a similarity between the growth of the mandible and the maxillae. In accordance with this assumption, Hellman considered the anterior part of the maxillary arch static, in conformity with Hunter's explanation, and looked upon the tuberosities as the sites of maxillary bone growth. It was explained that, since the additions of new bone were made on the posterior surfaces, the maxillae were pushed forward in a manner similar to the forward displacement of the mandible. This explanation is also at variance with the factual findings of Brash and, since it was shown that the maxilla becomes larger as a result of an exceedingly fine interplay between bone deposition and absorption, the anterior part of the maxillae is not static and

Fig. 5.

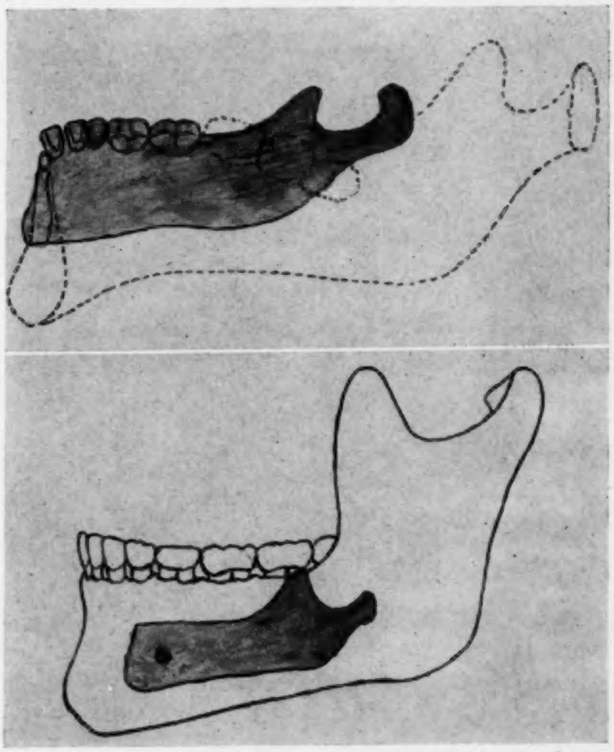

Fig. 6.

the infant maxillae do not form an integral part of the adult bone. Fig. 7 represents the infant and adult maxillae related to each other as suggested by Hellman, using the contact between the central incisors as the point of registration. Fig. 8 depicts a registration more in conformity with the explanation given to us by Brash.

The foregoing registrations of the young bone to adult bone serve to impress upon us that we cannot select a registration point without knowing the mode of enlargement of the bone in question. We must always bear in mind that any study of growth must be conditioned by experiments similar to those conducted by Brash. For more than 200 years, we have not applied our imagination to correct the error made by Hunter.

On the other hand, our imagination carried us away in the measurements of growth changes and in the study of the relationship of the denture in relation to the rest of the head. It has been accepted that, with a standardized registration of standardized radiographs depicting different stages of development, it is possible to study growth. The acceptance of this thesis carries with it the assumption that the establishment of the correct registration point is no longer a problem, and that the problem of standardizing radiographs already has been satisfactorily solved.

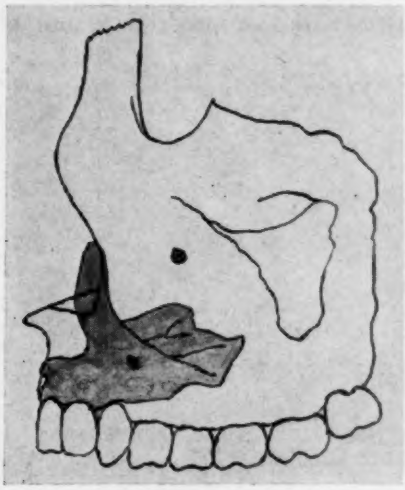

Fig. 7.

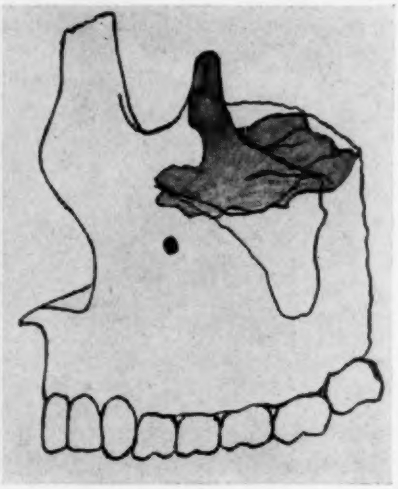

Fig. 8.

To determine the progressive changes in the face of the growing child, Broadbent made a most painstaking and sincere effort. He has standardized radiographic technique and after much study has given us a seemingly acceptable registration point. Because of the reliability of the source, the orthodontic profession accepted his findings without reservations and began to apply them in diagnosis. Unfortunately, Broadbent himself found it necessary to change the registration point several times, and proof is lacking that even the last registration point recommended could be used to any advantage in the study of growth or in diagnosis. Furthermore, the standardization of radiographic technique in private offices does not approach the accuracy obtained by Broadbent with permanently fixed x-ray tubes. Radiographs taken by the permanently fixed tubes at the Bolton Laboratories are more accurate than those taken in private offices, where the equipment must be set up separately for each radiograph. It may be argued that the error due to the inaccuracy of the setup is very small, but it must be remembered always that the actual change to be measured may be much smaller than the error. It is still an open question whether the study of growth should be based on serial radiographs of the same individual, taken at different ages.

If we look back on the earlier attempts to relate serial radiographs, we will note that much difficulty was encountered in finding the proper registration points. In 1931, Broadbent[5] published a paper, "A New X-Ray Technique and

Its Application to Orthodontia," in which he discussed the different methods of registration in use at that time, and gave us a newer method of relating standardized serial radiographs to each other. He used the roentgenograms of a child with a developing Class III malocclusion, where the pictures were taken approximately two years apart. These x-ray films were related to each other in the five different ways in use at that time; which is an excellent way of studying

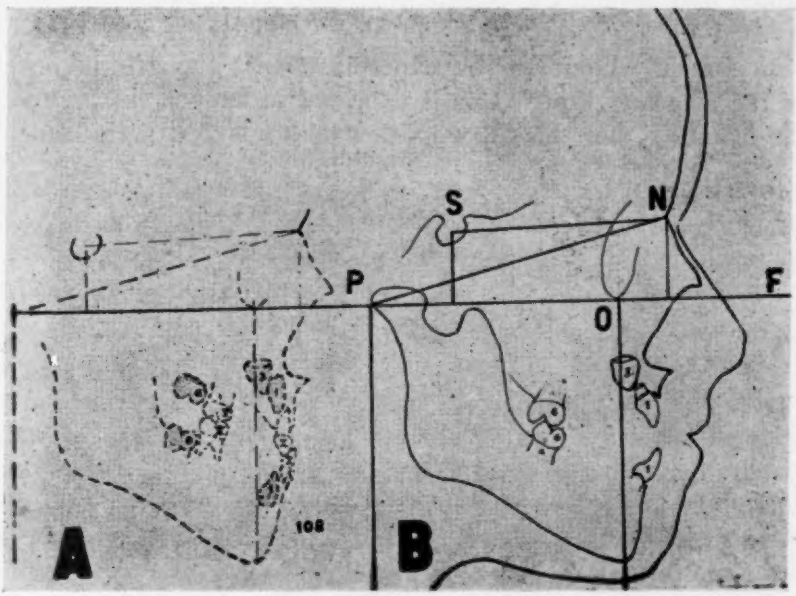

Fig. 9.—(From Broadbent: *Angle Orthodontist* 1: 45, 1931.)

the problem. Fig. 9 shows the tracings made from those radiographs, side by side. Tracing *A* in broken lines is that of a picture taken at the age of 6 years, 2 months, while tracing *B* in solid lines is at the age of 8 years, 5 months. The difference in age is fully reflected by these two tracings. It is shown beautifully in tracing *A* that the maxillary and mandibular permanent first molars have not erupted as yet. They have not reached the occlusal level of the deciduous teeth. It is common knowledge, requiring no further proof, that the permanent first molars travel occlusally through the alveolar processes during eruption until they reach the deciduous occlusal level. The eruption of the molars still continues beyond that level, and during the shedding of the deciduous posterior teeth the bite is normally raised. Frequently, the deciduous teeth are not able to reach this higher plane of occlusion and they appear to be depressed; the permanent teeth which follow them usually reach the higher occlusal plane. Tracing *B* depicts the stage where the permanent first molars have reached occlusal contact with the opposing teeth, and they seem to be permanently locked. The permanent anterior teeth have not fully erupted yet. The significant point to note in regard to these two tracings placed side by side is that they reflect a phase of growth as we see it happen. We know that the erupting teeth move occlusally through the alveolar processes and this is

equally true for both the maxillary and the mandibular teeth. Fig. 10 shows the tracings superimposed in "Frankfort relation" with porion *P* as the registration point. This is the first method of registration investigated by Broadbent, in which the sella turcica appears to have grown forward, together with the nasion. There is a definite indication that both the maxillary and the mandibular anterior teeth have grown forward. A closer examination, however, discloses that, according to this superposition, the maxillary permanent first molar erupted well beyond the deciduous occlusal level, and a new occlusal level was established for the permanent dentition. This is in conformity with the teachings of Brash, who found by experiment that the growing edge of the maxilla is the alveolar ridge. This is expected to happen in the maxillae and also in the mandible, but the superposition does not verify the conclusion we

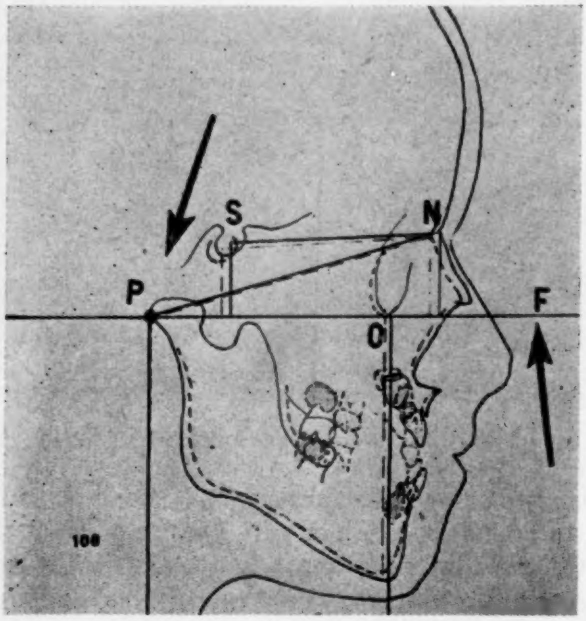

Fig. 10.—(From Broadbent: *Angle Orthodontist* 1: 45, 1931.)

have drawn from the position of the teeth in tracing *A* of Fig. 9. According to this superposition, the mandibular first permanent molar did not change its position during the two-year interval represented by the radiographs; the only change in its position is a slight forward translation. It is true that there appears to be a considerable growth on the posterior border of the ramus, the lower border of the mandible, and the chin, but these observations only add to the confusion and it becomes increasingly difficult to understand just what has happened. It was definitely established before that the mandibular first permanent molar erupts in a manner similar to the maxillary first permanent molar and it moves through the bone up to or beyond the occlusal level of the deciduous teeth. In tracing *A*, Fig. 9, it is shown to be unerupted and it has not made its appearance in the mouth. Tracing *B* shows the tooth fully erupted and, since it is in good occlusion with the maxillary tooth, it must have traveled

occlusally. We have seen this take place many times and, therefore, it can be stated as an indisputable fact that the mandibular first permanent molar does move occlusally through the bone during eruption.

Since this is unquestionably true, the information conveyed to us by the superposition is not consistent with the known sequence of events during growth; therefore, all conclusions drawn from this superposition of radiographs of the same individuals at different ages must be looked upon as unreliable. It is not possible to discuss the far-reaching effect of these representations at this time, but we may recognize with all its implications the fact that, because of the substantial downward growth of the maxillae, the position of the mandible in relation to the head is different at the different age levels. It is important, therefore, not to look upon the difference in the outlines of the mandible indicated by the superposition as actual growth, but rather as a combination of growth, a change in position, and an error in superposition. With this understanding, the difference in the position of the teeth suggested by the superposition cannot be interpreted as tooth movement.

Fig. 11 shows another method employed for relating the two radiographs of the same individual taken at different ages. In this method, tracing *B* is superposed on tracing *A* on the porion-nasion plane, using the mid-point between these landmarks as the point of registration. In order to fix the relationship properly, we must have either three points or a point and a line carefully selected. In the previous attempt, the Frankfort horizontal plane and porion were used, while in the present method the porion-nasion lines are superposed at their mid-points. There is no proof that either one of these methods is more accurate than the other, but it is made clear that the first method was not entirely satisfactory; otherwise our research men would not have looked for a more acceptable method of superposition. According to this method, the sella turcica remains more stationary and the amount of deposit on the nasal area is much smaller than in the previous instance. The indicated forward growth of the anterior teeth is somewhat less, but a very heavy deposit of bone is shown on the lower border of the mandible. The occlusal level is lowered considerably more than in the previous instance. This entire change is due to the fact that tracing *B* was placed lower in relation to *A* than before, because the angle made by the porion-nasion line and the Frankfort plane is somewhat larger in tracing *B*. As a result, tracing *B* is slightly rotated in relation to *A*.

It appears that the method just described again was not entirely satisfactory, for now we come to another scheme proposed by Krogman (Fig. 12), in which tracing *B* is related to tracing *A* by superposing porion *P* and placing nasion *N* of tracing *B* on a line drawn through nasion *N* of *A* parallel to the Frankfort plane. Here we perceive an attempt to place a tracing *A* into a larger tracing *B* in such a manner that the superposition would indicate a more uniform increase all around. The forward growth of the entire upper face appears to be greater, while the distal and downward growth of the mandible is shown to be smaller than in the previous instance. It is interesting to note that while everything appears to be more uniform, the sella turcica is brought

further forward together with the orbit. The most consistent change in these three superpositions is the marked downward growth of the surface of occlusion, which can mean only that the alveolar process of the maxillae grows downward so rapidly that even errors in superposition cannot conceal it.

Fig. 11. Fig. 12.

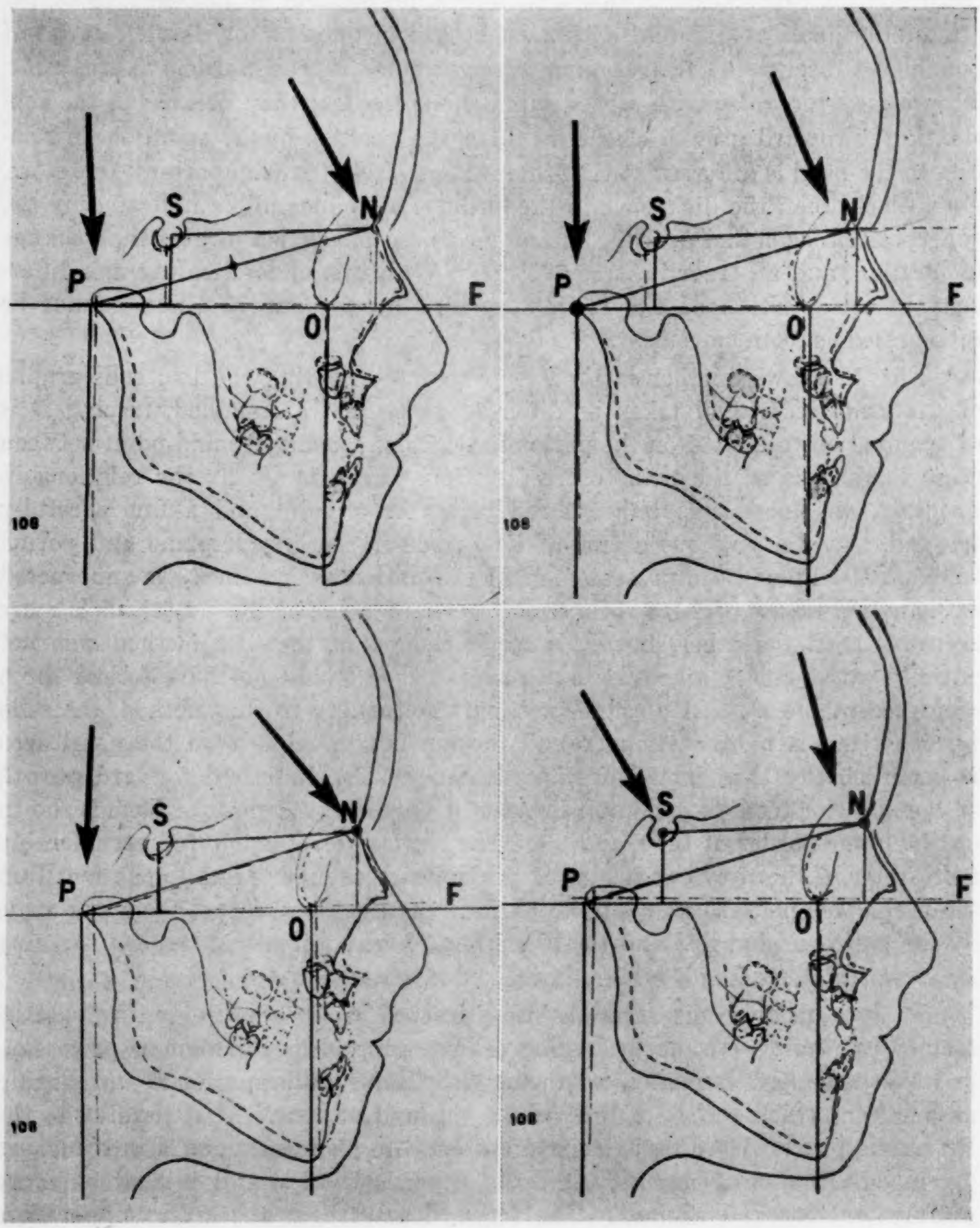

Fig. 13. Fig. 14.

Figs. 11, 12, 13, and 14.—(From Broadbent: *Angle Orthodontist* 1: 45, 1931.)

The fourth method of superposition was proposed by Todd (Fig. 13) and is the exact opposite to that employed by Krogman. In this method the nasion is registered and the porion *P* of tracing *B* is made to fall upon the Frankfort plane of tracing *A*. Here, the nasal area is assumed to be stationary, while the entire face shows a backward growth. This is more in conformity with the accepted teachings at the time this method was proposed. We may recall that the teachings of Hunter dominated our thinking, and the faulty analogy by Hellman, who stated that "the face grows from before backwards," places this method in the most acceptable position. It escaped notice, however, that if the teachings of Hunter and Hellman are correct, all these superpositions must show the maxillae of the two stages of growth superposed on each other at the median point, between the two central incisors. At the same time, the mandibles must be similarly registered. It is needless to say that this does not happen in any one of the proposed superpositions and the question arises as to just how much reliance can be placed on any of these methods.

As a direct result of his studies at the Bolton Laboratories, Broadbent came to the conclusion that none of these methods of superpositions are acceptable. In his article he states: "As valuable as these several methods of superposing orthodiagraphic tracings for measuring facial growth may be, it would seem to the author that the areas in the cranial base that have not changed, offer a more precise basis for relating tracings and, consequently, a more accurate method of measuring growth and development in the living head. Therefore, when we have an unchanged base common to two or more subsequent pictures of the same child, such as the area including the sella turcica and nasion of this series, we superimpose them on these landmarks. In the last figure (14) the tracings 'A' and 'B' have been superimposed with their planes N-S coinciding. The relation of N to S has not changed between the time these pictures were taken, and Fig. 14 shows the greatest increase in growth between S and P and along the lower border of the mandible and the posterior border of the ascending ramus." Here, Broadbent interprets the change in the position of the mandible as actual growth, forgetting to take into account that the occlusal level has been lowered considerably. This appears to be the case, for he further states: "This roentgenographic method has the added advantage of disclosing changes, not only of the teeth that have erupted, but it clearly shows the rate and amount of growth and path of eruption of the unerupted teeth." It seems that Broadbent made this statement without fully interpreting the superposed radiographs.

This method of superposition is based upon the observed fact that the distance between nasion *N* and sella turcica has not changed during the interval of time represented by the two pictures. Actual measurements confirm this observation, and there are two possible explanations of this condition. The first explanation, which was given to us by Broadbent, that both the nasion and the sella turcica are static or unchanged during growth, is untenable; for we know that both the frontal bone and the nasal bones increase in size as a result of growth, which cannot take place without surface deposition. Since the

nasion is the point where the nasal bones meet the frontal bone, there must be bone deposited at that point, but if bone is deposited at that point, the nasion cannot remain static and, therefore, we must seek another explanation.

The second explanation takes into account changes at the nasion with a corresponding change at the sella turcica and, since the distance between them remains the same during the change, we must explain that a change at these points does take place during growth but the changes are equal in amount and are in the same direction. Thus, while the distance between them does not change, the *N S* area is not static. The first explanation must be rejected, for we have shown that the nasion cannot remain unchanged. If the second explanation is correct, then both the nasion and the sella turcica change, and therefore they cannot be used as points of registration.

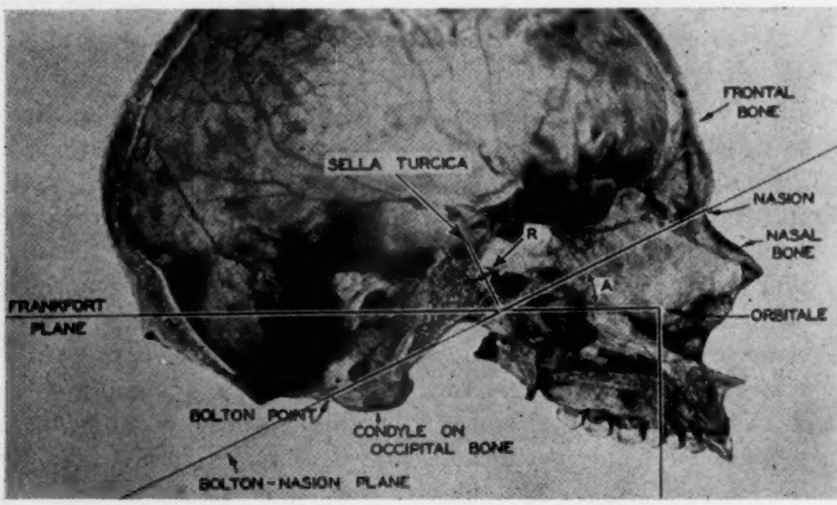

Fig. 15.—(From Broadbent: *Angle Orthodontist* 1: 45, 1931.)

It is interesting to note that six years later Broadbent himself abandoned his original method of superposition and gave us still another method. It is clear that Broadbent recognized the shortcomings of his first attempt; therefore, he made several alterations hoping to eliminate many of the objections just named. The method now used at the Bolton Laboratories takes into consideration the fact that, during growth, a change will take place in any point we may use as a point of reference. It is recognized further that there are no fixed or unchanging areas in a growing individual, but it is believed that a single theoretical point around which growth takes place can be accurately located. The determination of this point depends upon the accurate location of the Bolton plane, which now is accepted as the most unchangeable area in the entire head. It is determined at its anterior end by the nasion, and on its posterior end by the highest point in the profile of the notches at the posterior end of the condyles of the occipital bone (Fig. 15). The registration point *R* is the mid-point of the perpendicular drawn to the Bolton plane from the center of the sella turcica. If we inquire into the accuracy of this method of determining *R*, we will note

that the Bolton plane seems to be the most stable plane in the head because of the specific method of superposition used at the Bolton Laboratories. The registration point *R* is found to be a fixed point because it enables us to place a smaller tracing within a larger tracing in such a manner that the increase in size is approximately the same in all directions. Proof is lacking that either the Bolton plane, the registration point, or the method of superposition is correct. The apparent stability of the Bolton plane and the registration point is caused by the fact that the mode of enlargement of the head and the face is preconceived and the points and planes are selected to satisfy this preconceived notion. The method of superposition merely states that the enlargement does take place according to what is believed to be correct. This approach is erroneous, for the investigation is begun with an answer to the problem which is to be investigated. The registration point is located in such a manner as to give the kind of answer that was originally conceived. This is not permissible, and let us further investigate the accuracy of the method just described.

The registration point in itself is not sufficient to properly superpose the related pictures. Broadbent suggests: "Because of prolongation of the perpendicular to the registration point "R" below the Bolton-nasion plane, passes through the face at an oblique angle to the plane of occlusion of the teeth, a measure of the changes from this plane and the diagonal Bolton plane is awkward, and the measurements therefrom do not lend themselves to easy comparison to the orthodox method and results of the anatomist and anthropologist, therefore, *the Frankfort horizontal plane of the initial record of each child is added and is maintained in a fixed relation to its Bolton Plane.* See Angle A Figure 15 permitting the use of the perpendicular orbital plane which passes through the dentition about right angles. Measurements taken from these two planes are then a record of change from the more constant Bolton landmarks." This is equivalent to stating that the Bolton planes are kept parallel to each other in all subsequent pictures, but at the same time it is an admission that the angle *A* varies in the different radiographs. In other words, the Frankfort horizontal plane is not stable in its relation to the Bolton plane as growth progresses. If this were not the case, the Frankfort plane could be marked on each radiograph. By making the Bolton planes parallel, we impose the other necessary conditions for definite registration and thus we have a basis for comparison. Since angle *A* varies during growth, it definitely establishes the fact that the relationship of the Bolton plane to the Frankfort plane changes. There is no way we can determine which one of these planes changes and which one remains stationary, but it is more likely that they both change so that we may use either one as the stationary plane of reference. To be sure, the results will be different, but unquestionably one would be as good or as bad as the other. There is the very grave question as to whether the superposition of radiographs taken at different ages of the same individual actually indicates growth.

Broadbent gave an excellent composite drawing of the "Normal Developmental Growth of the Face," showing changes from infancy to adulthood (Fig. 16). Five different drawings were superposed according to the Bolton method.

The registration point was the same for all and the Bolton planes were kept parallel. The skull of a 1-month-old infant is well within the skull of the adult and the implication is that the difference in size and outline represents growth. It is well to observe that, according to this representation, the head and the face enlarge almost evenly in all directions, which on first glance seems very plausible. If, however, we study this chart and trace the outline of the infant mandible and that of the adult mandible on the same sheet of paper in the exact relation shown by the chart (Fig. 17), then we will observe that during growth the adult mandible has moved into a different position. But this differ-

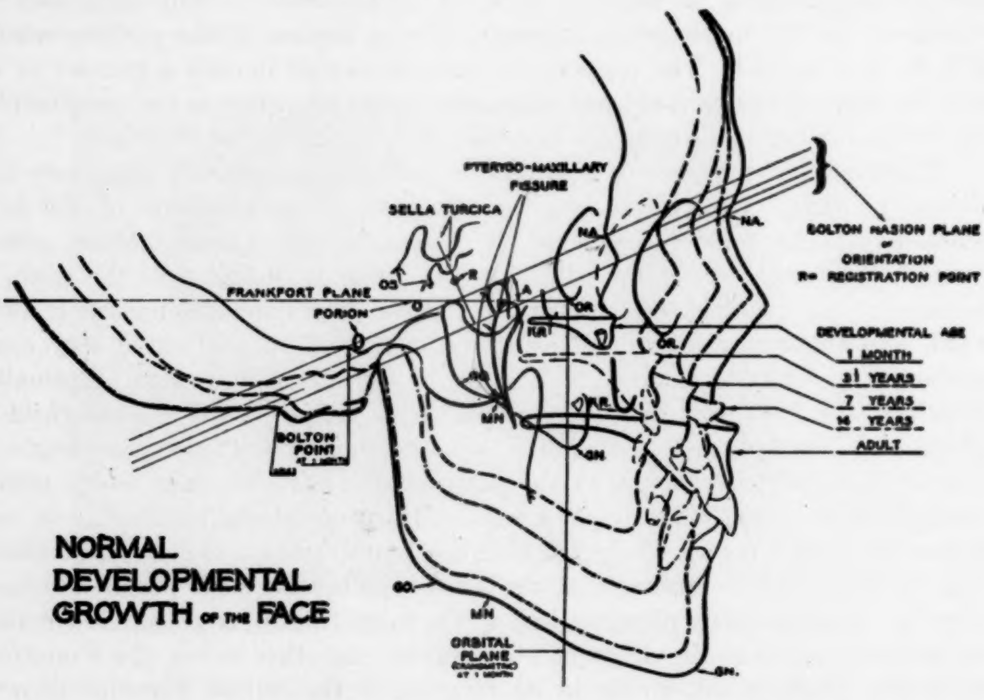

Fig. 16.—(From Broadbent: *Angle Orthodontist* 1: 45, 1931.)

ence in position cannot represent growth alone, and we are forced to conclude that in addition to becoming larger, the adult mandible also moved into a different position. We must remember that such differences in position are repeatedly interpreted as growth, and, while it may be argued that the superposed pictures indicate changes in the face as a whole, the evidence is too overwhelming to confirm the fact that conditions which do not exist are read from these radiographs. Broadbent states: "This roentgenographic method has the added advantage of disclosing changes, not only of the teeth that have erupted, but it clearly shows the rate and amount of growth and path of eruption of the unerupted teeth." This is a full admission that positional changes are not taken into consideration, and for this reason the interpretation regarding growth must be misleading. The change in positional relationship is so definite that it is clearly shown by any of the forgoing methods of superposition. The other

growth changes are so small that we cannot be sure that the error in superposition is not greater than the actual growth. For this reason the indicated changes are not dependable, and are of minor significance.

A more acceptable superposition may be obtained by tracing the infant and adult skulls on separate sheets of paper (Figs. 18 and 19). In order to show the actual change in size, the smaller mandible may be superposed on the larger mandible in accordance to the explanation given by Brash. The skulls

Fig. 17.

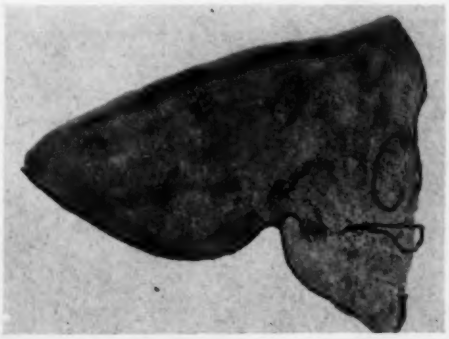

Fig. 18.

thus registered are shown in Fig. 20. This superposition roughly indicates that the mandible enlarges by surface deposits and absorptions, which is in conformity with our best concept of growth, but the changes in the skull as a whole cannot be judged from this figure. It becomes clear, then, that in order to study growth changes in any one bone, we must superpose the tracings of the bone in question, otherwise we may get a picture which gives a combination of growth and positional change.

To illustrate this, let us examine (Fig. 21) the evidence Brodie presented in his discussion of extraction. In his discussion he says: "In those cases in which extraction has been resorted to, it has been demonstrated that the molars are brought forward to a considerably greater degree than the incisors

taken back. The latter teeth have been shown to behave as two armed levers with their apices going farther forward than their original position." Fig. 21 is offered as an illustration to show the growth changes and the movement of the teeth during orthodontic treatment after extraction. The tracings show that

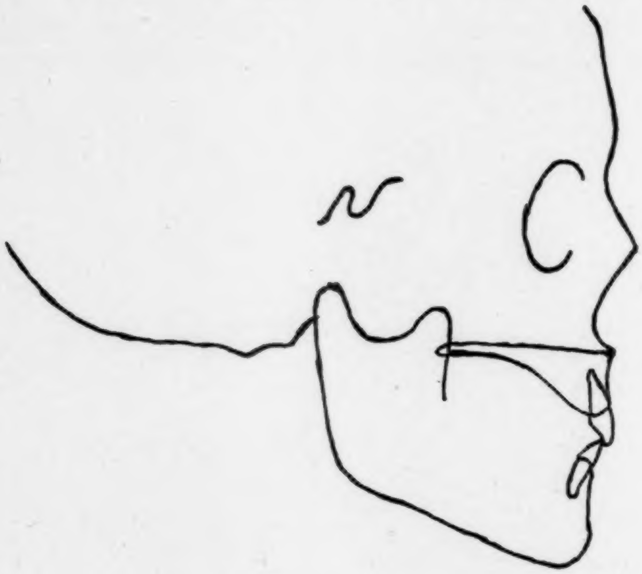

Fig. 19.

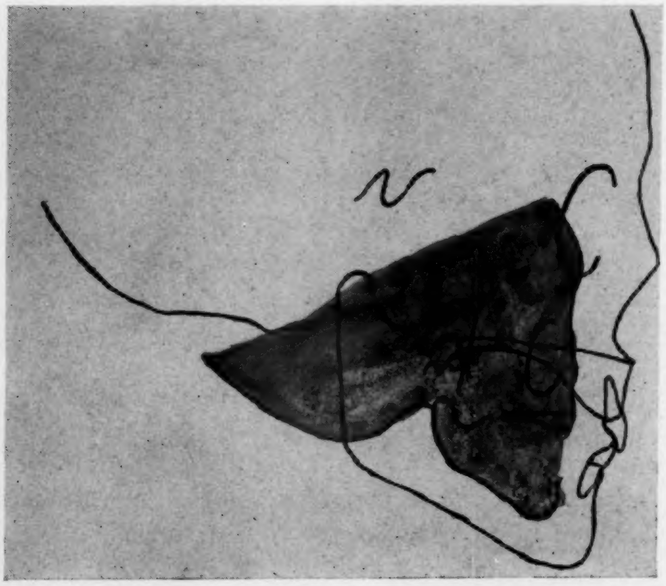

Fig. 20.

there was considerable change in the size of the mandible as suggested by the difference in outline of the lower border and the chin. It also shows that the molar teeth moved forward an amount equal to the difference between the

original position and the final position. The incisor teeth even moved forward during treatment, although an effort was made to move them backward. This interpretation does not take into consideration positional change and, if a tracing of the mandible after treatment represented by the full lines were placed over the dotted outline (Fig. 22), it would be seen that no perceptible change in the size of the mandible had taken place and that the teeth moved through the bone very much less than was indicated by Brodie's superposition. It is to be

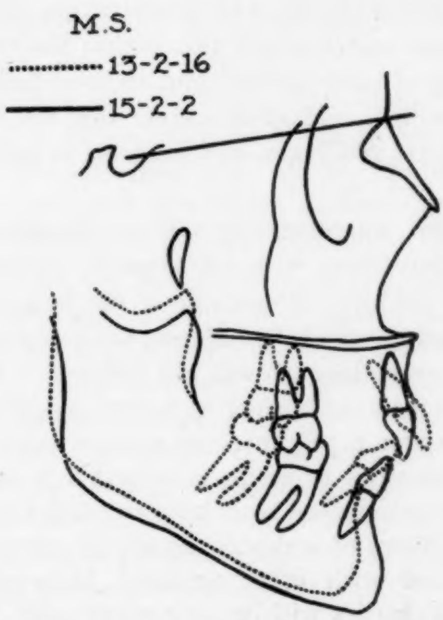

Fig. 21.—(From Brodie: *Am. J. Orthodontics and Oral Surg.* **30**: 444, 1944.)

Fig. 22.—(From Brodie: *Am. J. Orthodontics and Oral Surg.* **30**: 444, 1944.)

noted that Broadbent's first method of superposition was used, but the important thing is that the related tracings are used for the interpretation of tooth movement, which is erroneous. In this particular case, the change induced by the use of intermaxillary elastics also must be added. Therefore, it is definitely established that the growth of the face and head cannot be studied by one single registration point. To study the growth of any part, the tracings of the part under

investigation must be superposed; otherwise, the entire picture will be distorted. Thus, we may make the general statement that the results of any investigation of the growth of the head and face will be distorted if we make a registration of the skull as a whole; each part must be studied independently of every other part.

It is hoped that this critical review of the methods employed in the study of the growth of the face will not be looked upon as destructive criticism. I am intensely aware of the trend this type of investigation follows. I feel that it is necessary to make a clear statement of the several faulty concepts in order to prevent the undertaking of many sincere and arduous tasks in the future, based on such concepts. There is a very great danger that we shall be laboring under false premises for the next 200 years, and progress in orthodontics will be very much retarded.

It is imperative that we constantly use our imagination to formulate an acceptable hypothesis consistent with our present knowledge. It is not consistent to teach to our students the growth of the face as described by Brash, and then devise diagnostic methods based upon the superposition of radiographs. These two methods of evaluating growth are different. Brash's explanation of enlargement is based on fact established by actual experiment, while the method of superposition is based on a preconceived motion which has not been proved. A method of superposition can be accurate only if it is conditioned by the facts found by Brash. Furthermore, we must keep in mind always that isolated facts regarding the various phases of orthodontics are of very little value unless they are properly coordinated with other accepted knowledge. Advance in the science and art of orthodontics will be very much more rapid if we look upon the growth of the individual in his environment, and recognize that environment and disease may have a harmful influence on his growth and development. But we must understand how the enlargement of the face takes place, so that we may be able to explain the effects of those injurious influences. Diagnosis should be based upon the full understanding of the mechanism of growth, and treatment will be more intelligent if, at the stage treatment is instituted, we know more definitely what has happened before and what may happen after orthodontic interference.

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RECENT RESEARCH FOR DIAGNOSIS

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I RECENTLY spent a few hours with Dr. Takahashi, from Tokyo, Japan. It was a great pleasure to hear a comment of his on the overworked question of appliance preference. He said that, after all, the appliance was only a tool of the orthodontist (the sculptor uses many chisels—long, short, curved, and straight); the important factor is that the chisel must be sharp.

Happily, orthodontists pay less attention to appliances today in their general discussions and meetings. It is widely recognized that the appliance is simply a tool—a tool that must accomplish a specific duty efficiently. If the tool does accomplish the prescribed task, we certainly cannot heap our orthodontic failures and shortcomings on its back. The blame, if it can be called that, must be attributed to the taskmaker—not because the orthodontist lacks mechanical adeptness, because there is no appliance that is not easily mastered in short order, but because the orthodontist has failed in his individual problem of case diagnosis. This means balancing what must be done with what can be done and then assigning the proper tools to the task.

Etiology is another term that burdens the clinician. (I emphasize clinician and not the teacher or research man.) Etiology usually is listed as early loss of deciduous teeth, heredity, or bad habits. As clinicians, we can do nothing about the heredity, we cannot retrieve the deciduous teeth, and whether the bad habits are due to the malocclusion is a moot question. It is the wiser policy in the majority of instances to begin the diagnosis on conditions actually present, not on a fancied theory of etiology. There is enough guesswork in the future without bringing up the past.

These statements are perhaps strong and a bit unfair, but it is a way of emphasizing that the orthodontist is presented with a dental occlusion that must be remodeled, not material for the construction of a new dental occlusion or a crystal ball to reconstruct what might have been.

Limiting our attention to the stomatognathic system, we can conveniently divide that field of interest into three basic parts: (1) neuromuscular, (2) facial skeletal, and (3) dental.

Imagine, if you will, an edentulus skull—just a collection of dry bones that represent a facial skeletal pattern. Add to that skull a neuromuscular system

Presented at the meeting of the Central Section of the American Association of Orthodontists, Chicago, Ill., Oct. 18, 19, and 20, 1953.

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to tie the mandible to the cranium and to transform the picture from the static to the functional. Now we have the situation that confronts the prosthodontist, who must insert a denture within the confines of a specific skeletal and neuromuscular pattern—patterns that allow a variable amount of tolerance. The prosthodontist has learned that if any compensating must be done, it should be done to the denture, not to the muscle and skeletal pattern.

If we wanted to create our own Pinocchio and reached into a barrel of mandibles and at random chose a mandible, into a barrel of craniums and upper faces and picked one, into a barrel of neuromuscular systems and chose one, and then into a barrel of natural dentitions and selected one, the resulting face might be startling.

Carrying the fantasy even farther, for Pinocchio was only a small boy, and imagining the individual growth patterns of all the parts just mentioned, we can visualize what individual variation means and how a static analysis based on one factor, the dental arches, is bound to result in a high percentage of failure.

In order to come to an intelligent diagnosis, we must discover:

1. What neuromuscular pattern exists and what are its tolerances.
2. What facial skeletal pattern exists and what are its demands upon the denture.
3. How can we adjust the teeth so that, as an esthetic unit, they are in harmony with the neuromuscular and facial skeletal patterns.

Of equal importance is the dynamic analysis:

1. What changes would occur in the neuromuscular, facial skeletal, and dental pattern without orthodontic treatment.
2. What changes will occur in the neuromuscular, facial skeletal, and dental patterns during the proposed orthodontic treatment.
3. What changes will occur in the neuromuscular, facial skeletal, and newly developed dental pattern after the proposed orthodontic treatment.

In attempting a discussion of these problems, it would be appropriate to start with the topic we know the least about and over which we have the least control. Naturally, this topic is the neuromuscular pattern.

NEUROMUSCULAR PATTERN

Starting with more or less basic research, electromyography is the method of approach selected by most researchers recently. Being more familiar with their work, a brief report of studies being done at Northwestern University by Jarabak, Perry, and Zwemer will be presented.

The variation of electrophysical phenomena emitted from bodily tissues in different physiologic and pathologic states has long been utilized by medicine for diagnosis. Two classic examples could be cited in the electrocardiograph and the electroencephalograph. A third and less well-known method is found in the electromyograph (EMG).

The EMG follows a long progression of improvements upon Einthoven's original string galvanometer, constructed in 1903.

When a muscle contracts there are physical, chemical, thermal, and electrical changes taking place in the individual fibers. The principle of the EMG's working is dependent upon these latter minute electrical discharges. The diminutive quantity of these electrical phenomena necessitates amplification, which is possible with the electronic tube. The enlargement of these action potentials does not alter their basic pattern, but merely magnifies it to a suitable degree for recording with a penwriter, tape recorder, or camera.

Small, round, silver electrodes are attached to the skin surface over the motor area of the muscles to be tested. The electrodes then are firmly attached by means of celloidin. Through a small window in the electrode surface an electrode paste or jelly is inserted to reduce the resistance between the muscle and electrode. A resistance of less than 5,000 ohms is imperative for suitable records.

The patient is placed in a grounded Faraday room. The electrodes are plugged into a terminal board, which is connected to the amplification mechanism. The amplification system is continuous with the recording medium and an audio unit.

Northwestern University has used a penwriter or crystograph in conjunction with the audio unit in all of its studies.

Moyers, at the University of Iowa, and Pruzansky, at the University of Illinois, did the original work with the EMG in the dental field. Other studies are under way at Tufts College, the University of Toronto, the University of Illinois, and Northwestern University, to mention only a few of the institutions.

Moyers noted a difference in the action potential patterns recorded on a crystograph in Class II, Division 1 (Angle) cases, when compared to normal occlusion. The degree of this difference and the exact nature was not thoroughly explained, but the variation present was cited.

In clinical and experimental medicine, much work with the EMG has been done in the field of kinesiology, the study of movements. It was in this area that present studies at Northwestern were begun. This phase of dental research has not matured as yet to a full diagnostic stature. Its limitations and restrictions are many. Its primary function today is to give us a better understanding of the physiologic activity of muscle tissue, another facet of the stomatognathic system that has remained unpolished only because we have not had suitable means of study.

At the present time, graduates at Northwestern University are engaged in studies to distinguish any differentiating features noted in comparing functional patterns of normal occlusion to that of the Class II, Division 1 malocclusion and also to note any homogeneity of activity seen in individuals having similar occlusions.

Up to now, most of the data on this and other studies have been taken. They have not been thoroughly studied as yet. The records taken to date do concur with Moyer's findings; that is, that a definite action pattern difference is observable in Class II, Division 1, if compared to similar tracings in the normal occlusion group.

Fig. 1.

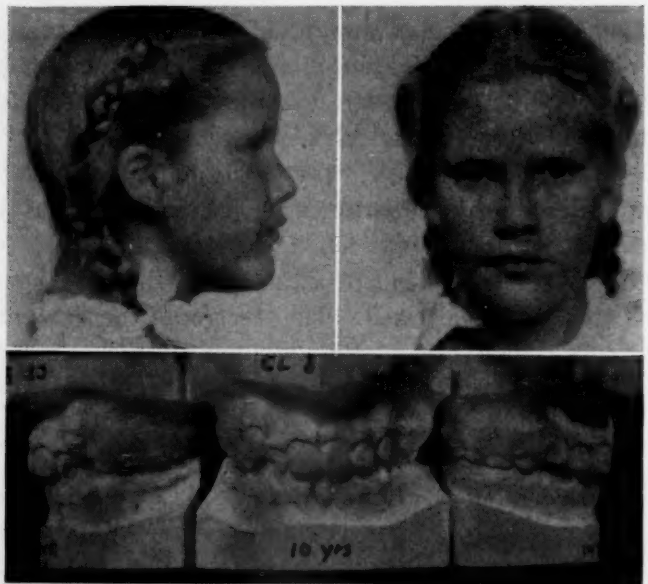


Fig. 2.

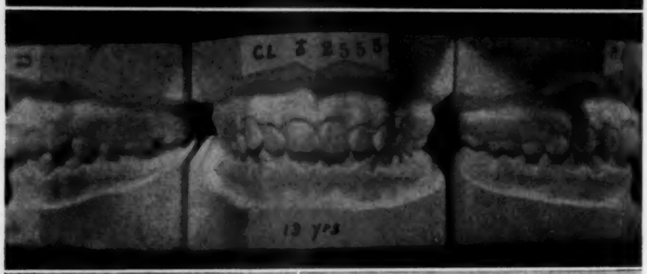


Fig. 3.

Fig. 1.—Photographs and models of 10-year-old patient before treatment.
Fig. 2.—Models at time of retention.
Fig. 3.—One and one-half years after all retainers had been removed. Slight clicking in both temporomandibular joints noted.

At the existing time the study seemingly has been fruitful, with many avenues of future investigations uncovered.

It must be remembered that these studies were done during function and that each individual has a relative degree of freedom in his own functional patterns; therefore, it would be unwise, unwarranted, and untimely to present an analysis of the data prior to a thorough study of all the records.

The diagnostic use of the EMG in orthodontics is, as yet, unproved. Its future path is obstructed by many obstacles, such as expensive equipment, thorough training, bulky apparatus, and time-consuming effort. Perhaps, with a short passage of time and full application of man's ingenuity, the true worth of electromyography in dentistry will be realized.

Neuromuscular clinical research with direct application to diagnosis consists in the main of studies on mandibular position and the temporomandibular joint. Results of studies are available from many institutions, but orthodontic departments at Northwestern University and the University of Illinois have been especially prolific.

In the younger age group, functional problems (namely, mandibular displacement, rest position, path of closure, and clicking of temporomandibular joints) should be approached carefully and treated conservatively. It is not uncommon to hear the expressions, "The crepitus disappeared spontaneously," "The path of closure changed automatically," "The rest position doesn't seem stable," "He grew into a mandibular displacement," etc.

These statements take on meaning when it is realized that the three major parts of the stomatognathic system (muscle, bone, and teeth) grow and develop more or less independently. Individual variation is widely apparent between individuals, but within the individual it is quite often overlooked. Very little is static in the growing child; unit compensation and tissue tolerance receive their greatest tests during these years.

As adulthood is approached, the muscle pattern and the facial skeletal pattern reach a fairly stable condition, and it is then that functional stomatognathic discrepancies can be corrected confidently by dental adjustment.

An actual case will serve to demonstrate many of the facets of functional analysis during orthodontic treatment.

Fig. 1 shows the photographs and models of the patient at 10 years of age. After a period of observation and a year of full treatment, the models appear as in Fig. 2.

At 15 years of age, one and one-half years after all retention had been removed, slight clicking was noted in both temporomandibular joints (Fig. 3). A plastic treatment splint was placed to find the optimum jaw relation, and clicking disappeared. Three months after the splint had been removed, the clicking returned. The treatment was repeated, with the same results. At 16 years of age, severe clicking still occurred when the mouth was opened from the occlusal position (Fig. 5), but the function was smooth from the mandibular position, as shown in Fig. 6.

Fig. 4.—Splint used to obtain optimum jaw relation.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 5.—Occlusal position from which severe clicking of temporomandibular joints occurred.
Fig. 6.—Jaw relation from which no clicking occurred.
Fig. 7.—Bite plate and appliance worn to alter occlusal relation.

Bands were placed and vertical elastics were worn in conjunction with a bite plate.

Elastics were worn for three months, and clicking had not returned up to one year later. The lower left central incisor had dropped to the lingual, a result of the repositioning and the growth pattern.

As recommended by Thompson,[13] it seems to be a wise policy to check at every appointment the condylar function, path of closure, rest position, and premature occlusal contacts. Orthodontic treatment should be coordinated with the attainment of smooth function, which, in most cases, means a rotary condylar motion from rest to occlusion, an upward and forward path of closure, an adequate interocclusal clearance, and the elimination of undesirable cuspal contacts. In most instances, the end of orthodontic treatment should mean the attainment of excellent stomatognathic function. This often is overlooked by concern for esthetics and dental interdigitation. Malfunction does occur for other reasons, but only too often it is the result of orthodontic treatment.

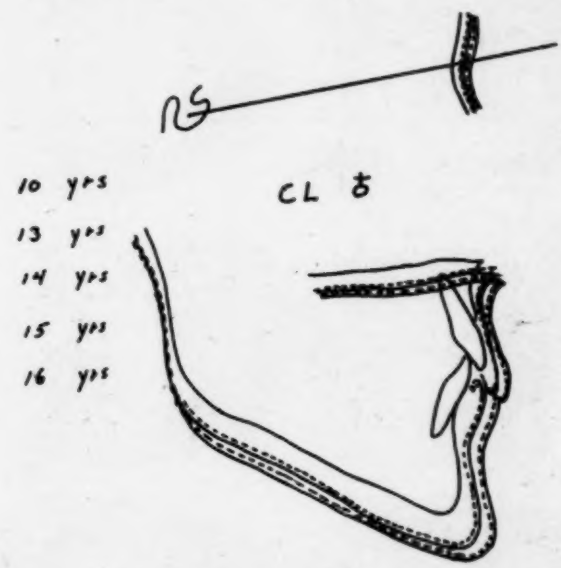


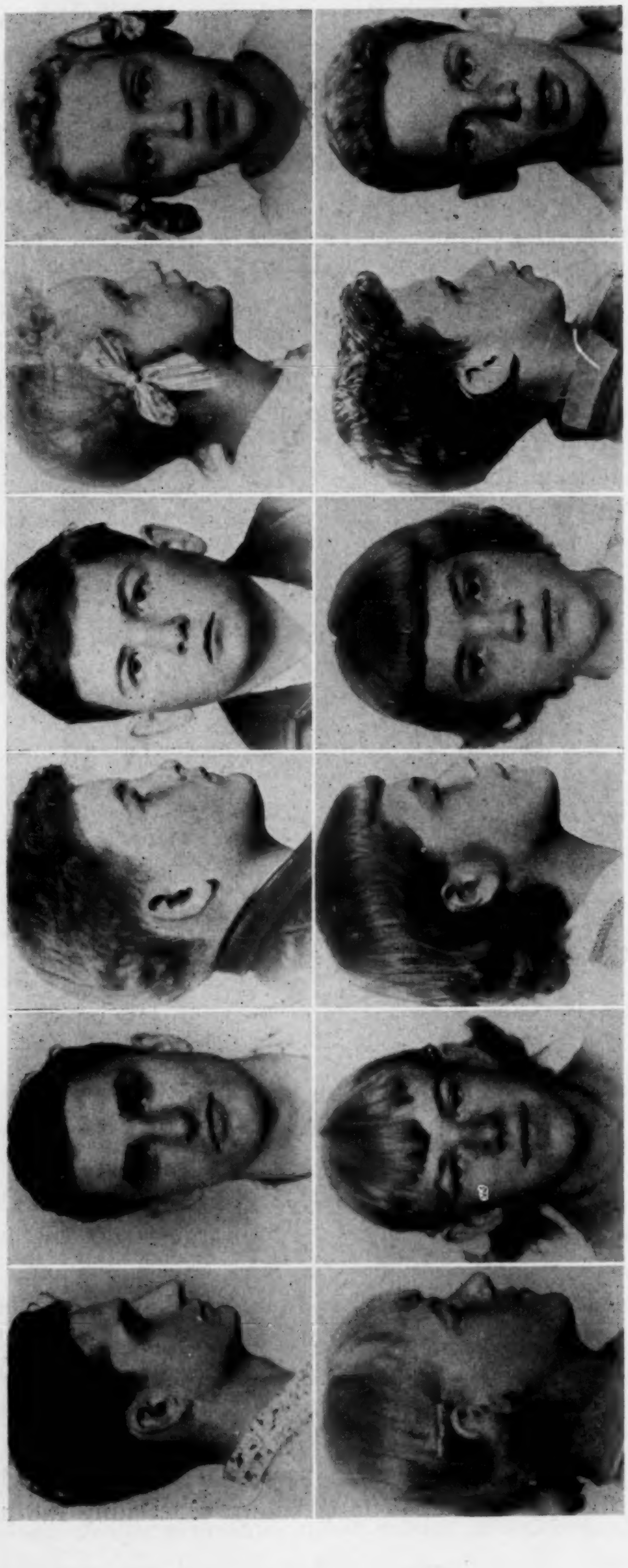
Fig. 8.—Tracings indicating growth trend, which, along with apical base relation, inclination of incisors, and tight musculature, resulted in temporomandibular joint malfunction.

Along another vein, the work of Rogers[12] in myofunctional therapy is well known. Recent years have brought to light the considerable interest shown in Europe, and especially England, in muscle re-education. Ballard and Gwynne-Evans[1, 5] have introduced various techniques to help orthodontic appliances achieve a lasting result. Very successful in many instances, there is some evidence that the old pattern tends to return after the supreme effort for esthetic improvement is relaxed (for instance, after the female patient has succeeded in catching her man).

In spite of the achievements of basic research, clinical research, and clinical experience, it still remains that little is known concerning the neuromuscular

Fig. 9. Fig. 10. Fig. 11.

A. A. A.



B. B. B.

Fig. 9.—*A*, Tight muscle; long face; small ab difference. *B*, Loose muscle; long face; small ab difference.
Fig. 10.—*A*, Tight muscle; short, square face; small ab difference. *B*, Loose muscle; short, square face; small ab difference.
Fig. 11.—*A*, Tight muscle; narrow, thin face; large ab difference. *B*, Loose muscle; narrow, thin face; large ab difference.

Fig. 12. Fig. 13. Fig. 14.

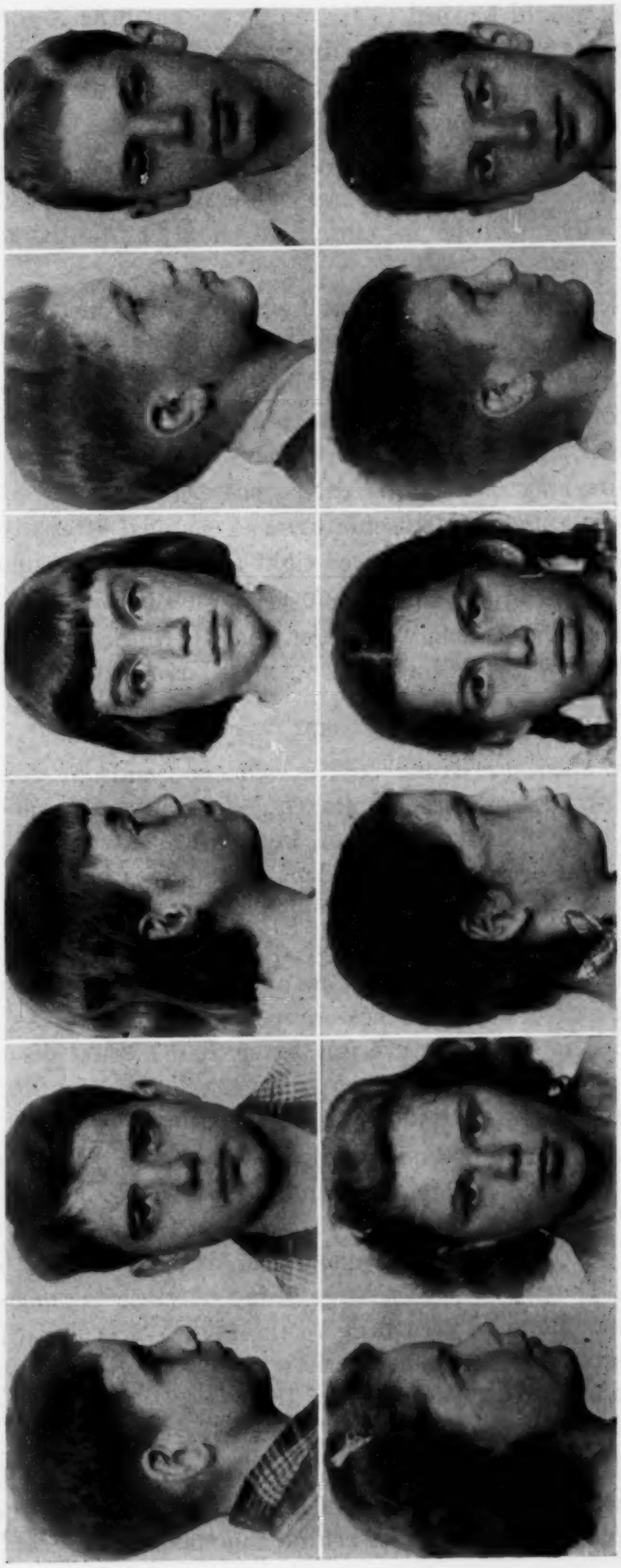


Fig. 12.—*A*, Tight muscle; long, wide face; large ab difference. *B*, Loose muscle; long, wide face; large ab difference.
Fig. 13.—*A*, Tight muscle; bimaxillary protrusion. *B*, Loose muscle; bimaxillary protrusion.
Fig. 14.—*A*, Note facial musculature. *B*, Same case, two years later.

mechanism. What would happen to the muscular patterns if the malocclusion remained uncorrected? What occurs during appliance manipulation? What is the status after treatment? Of all the things we do not know, the few that are known should be kept always in mind.

Of the tissues involved in orthodontic treatment (bone, muscle, teeth, and periodontal membrane) muscle is the most difficult to alter permanently. Our compensating usually must be in tooth movement, tooth grinding, or tooth elimination.

The clinical examination and the photographs sometimes aid tremendously in revealing present muscular conditions (Figs. 9, 10, 11, 12, and 13).

Lips that are easily held open, cheeks that are easily held out with the mouth mirror, and the tongue that is easily controlled with cotton rolls—all the little things—aid in determining the muscular factors that must be dealt with. Of course, a few years may change the entire pattern, as evidenced by Fig. 14. The loose, hypotonic-appearing musculature has changed after a year or two of growth and development to a pattern of tight and strong musculature.

In spite of the variety in muscle pattern and the variability encountered during growth periods, it is usually assured that the total muscle force becomes stronger, rather than weaker, if a developmental change does take place.

FACIAL SKELETAL PATTERN

If it had not been for Broadbent, untold thousands of dogs would have suffered the pains of orthodontic appliances, and we would know more about the properties of gold than an alchemist, but, as it turned out, Broadbent developed his cephalometer and the orthodontic graduates had new fields to conquer.

That their labors have been fruitful is evidenced by the widespread use of cephalometric analysis today. Of the many methods, Downs, Wylie, Margolis, and Northwestern University label those in most common use. As these methods have been explained in the literature far better than I could discuss them here, it might be best to start with a cephalometric radiograph and try to discover what direct value it might have in individual diagnosis.

An important factor in orthodontic diagnosis is the anteroposterior relation of the maxillary alveolar arch to the mandibular alveolar arch. With the use of the points "a" and "b" as defined by Downs, "a" representing the maxillary apical base and "b" the mandibular apical base, it is convenient to use the aNb angle (Reidel and Thompson). If a large group of subjects possessing excellent dental occlusion are graphed according to the angles SNa and SNb (Fig. 19), it is readily apparent that a characteristic of excellent occlusion is an aNb angle of from 1 to 5 degrees. Very few of the subjects have aNb values of more than 5 degrees and fewer have values below zero; aNb angles much beyond this range present increasingly difficult problems in treatment and prognosis.

A malocclusion possessing an apical base difference of 10 degrees (with the mandibular apical base 10 degrees behind the maxillary apical base) presents

a problem that is almost impossible of ideal solution. Incisor teeth would have to be tipped to unstable inclinations or an overjet, overbite problem remains. Prognosis is indeed unfavorable with extreme apical base imbalance no matter what type of malocclusion is present (Fig. 20).

Fig. 15.

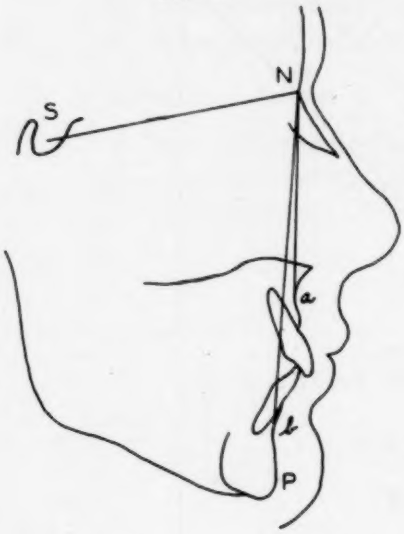
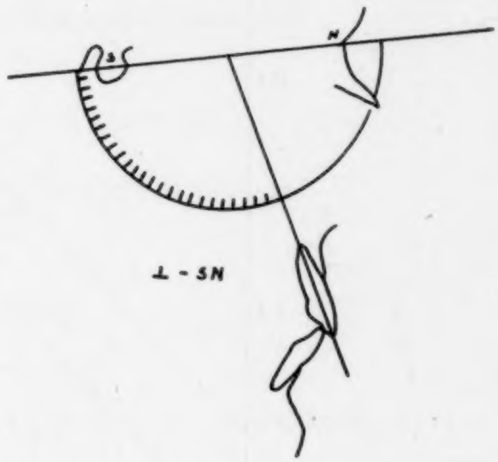


Fig. 17.



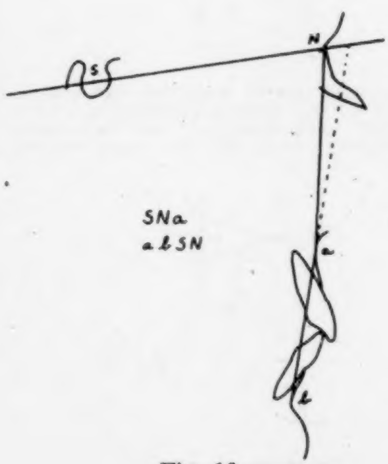


Fig. 16.

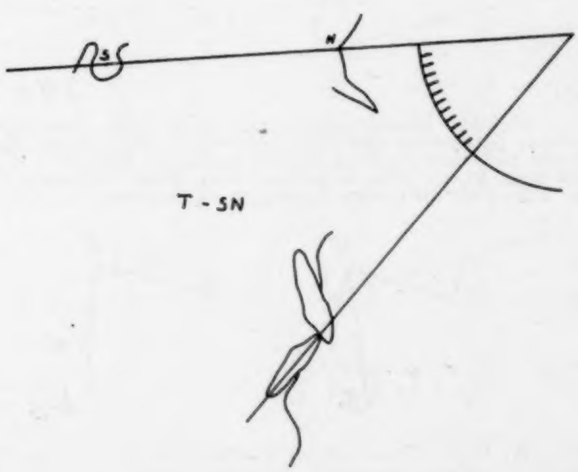


Fig. 18.

Fig. 15.—Points and landmarks necessary in evaluating apical base relation. *S*, Sella turcica; *N*, nasion; *a*, maxillary apical base; *b*, mandibular apical base; *P*, pogonion.

Fig. 16.—A method of evaluating the lateral apical base relation.

Fig. 17.—Method of measuring the labiolingual axial inclination of the maxillary central incisor to the SN line.

Fig. 18.—Method of measuring the labiolingual axial inclination of the mandibular central incisor to the SN line.

With point "b" ahead of point "a," the normal overbite-overjet relation is very difficult to retain and the extreme cases demand surgical assistance in treatment.

A more convenient method of relating the apical bases is by measuring the angle formed by extending the ab line to the SN line. This gives us a more accurate appraisal of the apical base relation because of the elimination of the third point (point N).

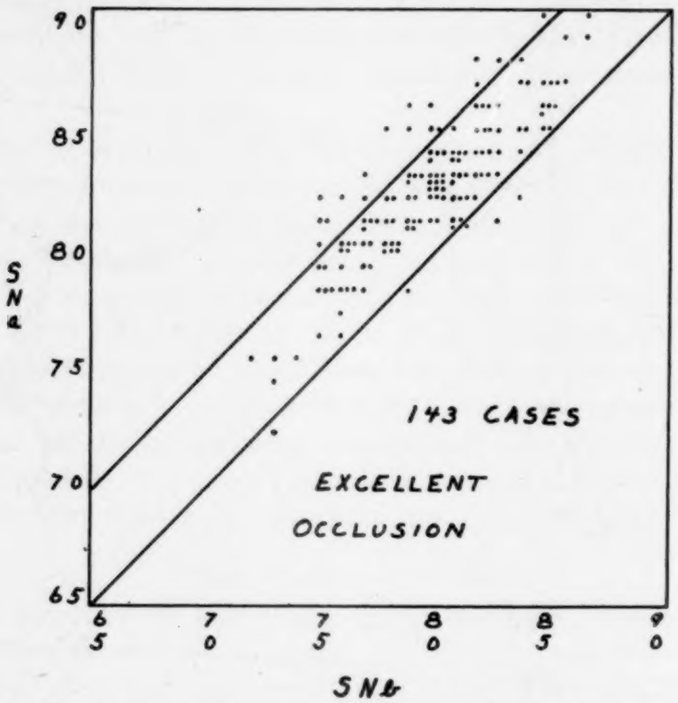


Fig. 19.—One hundred forty-three cases possessing excellent dental occlusion fall into a definite pattern on the SNa-SNb chart. The lower right half of the chart represents the area where the cases showing SNb to be larger than SNa would fall. The upper left half represents the area where SNa is greater than SNb. Between the diagonal lines fall the cases having the SNa-SNb difference from 0 to –5 degrees.

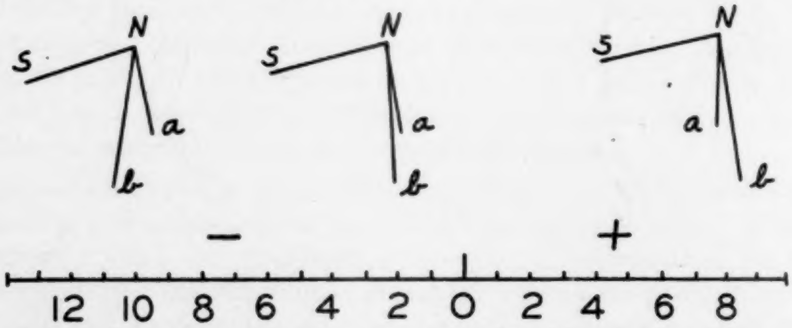


Fig. 20.—Prognosis and treatment of malocclusion is aided by a knowledge of apical base relation. Large minus readings (SNa greater than SNb) indicate a very poor apical base relation and unfavorable prognosis. Small minus readings indicate an excellent apical base relation and favorable prognosis. Large plus readings (SNb is greater than SNa) indicate a very unfavorable apical base relation and extremely unfavorable prognosis.

In addition to the apical base evaluation, an important point to note in the cephalometric tracing is the relation or prominence of the apical bases to point N (nasion) of the SN line. This is measured by the angle SNa. A large SNa angle indicates an anterodivergent dental area, and a small SNa angle represents a posterodivergent dental area.

With the use of angle abSN and SNa, it is possible to attempt an apical base classification, as follows.

A. Concave relation (abSN angle high)

1. posterodivergent dental area (SNa angle small)
2. neutrodivergent dental area
3. anterodivergent dental area (SNa angle large)

B. Straight relation

4. posterodivergent dental area (SNa angle small)
5. neutrodivergent dental area
6. anterodivergent dental area (SNa angle large)

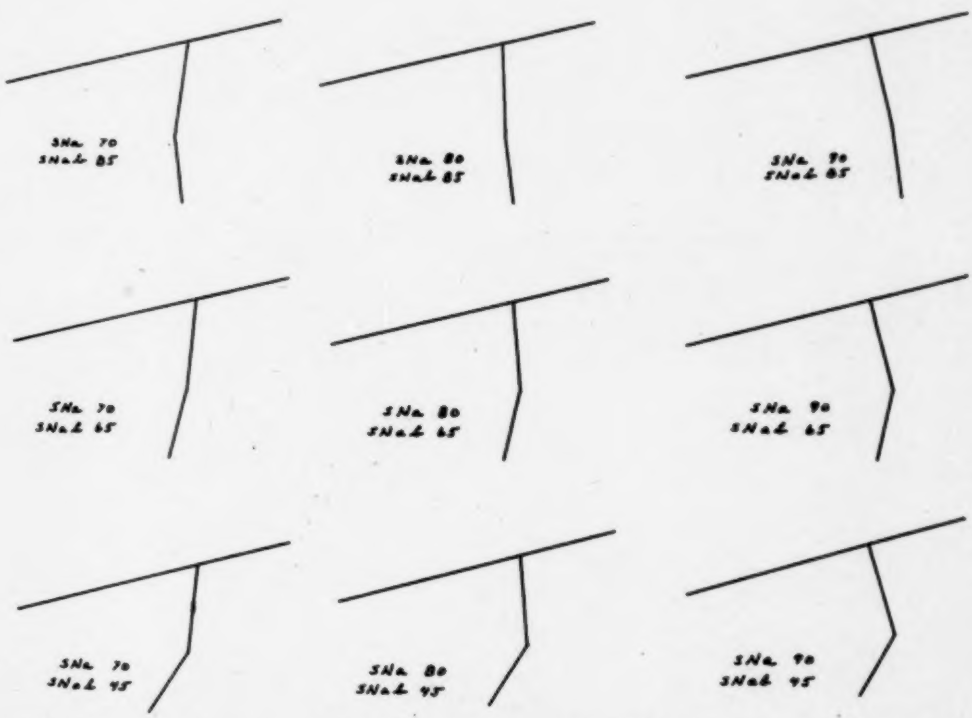


Fig. 21.—Various types of apical base relation as classified by the angle abSN and SNa. Rows represent concave, straight, and convex, while columns represent posterodivergent, neutrodivergent, and anterodivergent.

C. Convex relation (abSN angle small)

7. posterodivergent dental area (SNa angle small)
8. neutrodivergent dental area
9. anterodivergent dental area (SNa angle large)

After determining the apical base classification, the inclination of the incisors to the SN line is the next point of interest. It was found that in subjects with a high abSN angle and a high SNa angle the labial inclination of the incisors was rather great, the reverse being true with low values of abSN and SNa.

As correlations were higher with the maxillary incisor than with the mandibular incisor, it is probably a better policy to place more emphasis on the inclination of maxillary incisors in the treatment plan than on the inclination of the lower incisors.

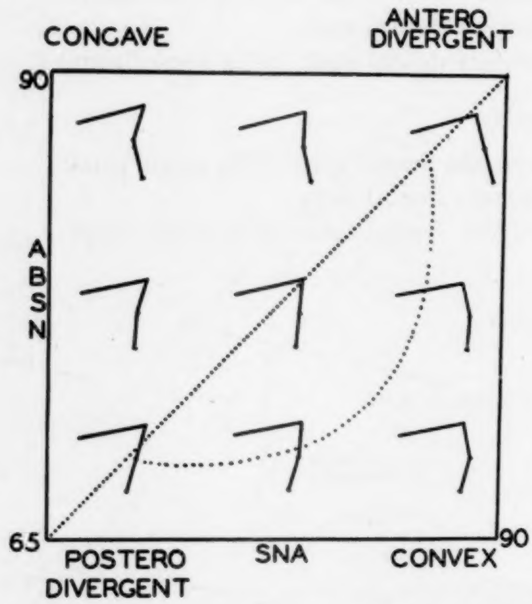


Fig. 22.—Summary chart. Most excellent natural occlusions fall within the dotted segment. More labially inclined maxillary incisors are found in the upper right section, while vertical or lingually inclined maxillary incisors are found toward the lower left corner.

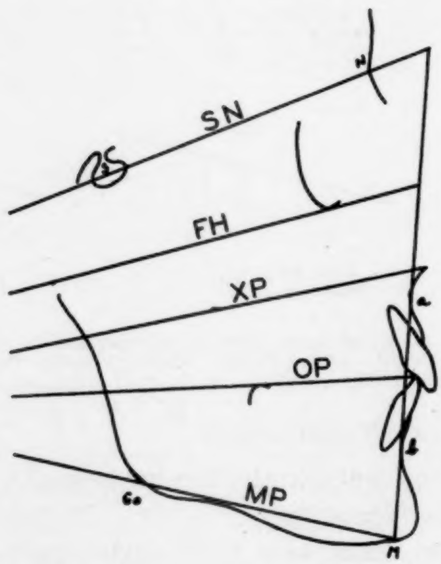


Fig. 23.—Horizontal planes. *SN*, Sella-nasion; *FH*, Frankfort horizontal; *XP*, maxillary plane; *OP*, occlusal plane; *MP*, mandibular plane.

Fig. 22 shows in chart form the main points discussed. Most excellent natural occlusions fall within the dotted segment of a circle, the cases toward

the upper right corner possessing labially inclined maxillary incisors (up to 121 degrees to the SN line) and the cases toward the lower left corner possessing more vertical maxillary incisors (to 89 degrees to the SN line).

Thus, it is possible, within limits, to compare an individual case to the chart and, by means of apical base relation and incisor inclination, reach a more accurate prognosis and treatment plan.

Another interesting factor in cephalometric analysis is the behavior of the horizontal planes (sella-nasion, maxillary plane, occlusal plane, and mandibular plane). The mandibular plane and sella-nasion plane serve as a gauge of anterior facial height to posterior facial height. The mandibular plane and the maxillary plane aid tremendously in determining the amount of dental area available for the erupting teeth (Fig. 23).

A detailed cephalometric analysis method has been completed and is being prepared for publication.

GROWTH

With the cephalomtric skeletal evaluation, we have some idea of the foundation upon which to perform the necessary occlusal adjustments.

As the child is growing, the conditions found today theoretically could be changed tomorrow. Practically speaking, the skeletal pattern changes very little with growth in the individual case, with or without the interference of orthodontic manipulation, although there is evidence that orthodontic therapy may inhibit the forward movement of the maxillary apical base.

In spite of individual constancy of growth pattern, the pattern does vary between individuals. Figs. 24, 25, and 26 present examples of predominately horizontal, horizontal and vertical, and predominantly vertical facial growth.

Predicting the growth pattern without a series of radiographs is at present a risky business. However, certain points should be noted in diagnosis. Horizontal growth patterns predominate when angle NSM (nasion-sella-menton) is low, when the mandibular plane—sella nasion angle is low, when the maxillary plane—sella nasion angle is low, when the occlusal plane—sella nasion angle is low, when the abSN angle is high, and when SNb angle is high. Vertical growth predominates when these values are reversed.

There is considerable evidence that many cases present growth spurts out of the accepted pattern (Figs. 27 and 28). In what cases to expect the spurts is not accurately predictable, but at what age they are likely to occur is more readily answered.

As in other parts of the body, the most active growth period occurs earlier in girls (10 to 14) than in boys (12 to 16). There usually will be more growth during these periods to aid orthodontic therapy. Horizontal growers grow more horizontally, vertical growers grow more vertically, and spurts out of pattern are more likely to occur.

There is also a growing mass of evidence that early treatment, headgear or otherwise, is not the glowing picture that has been painted lately, but that is another story.

Fig. 24.

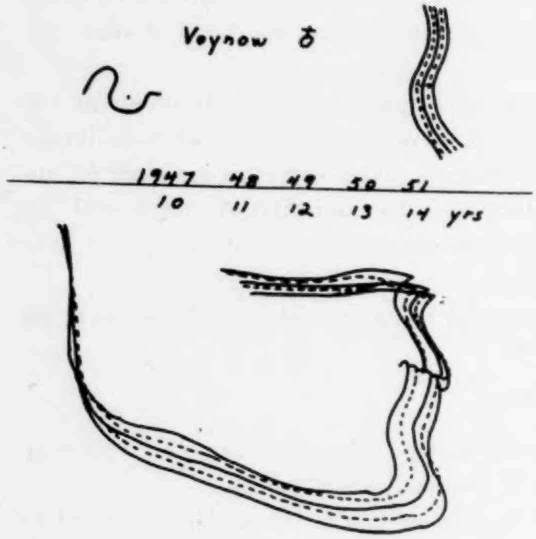


Fig. 25.

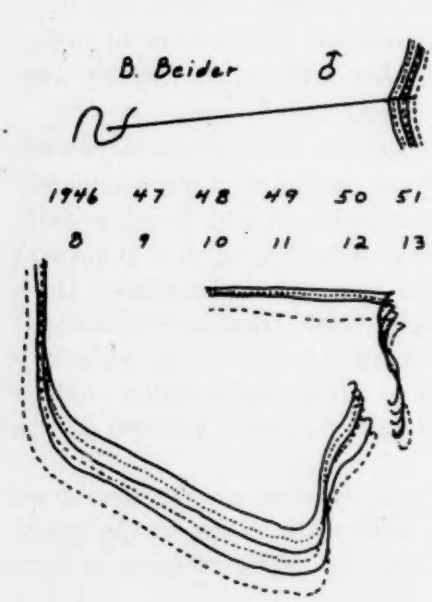


Fig. 26.

Fig. 27.

Fig. 24.—Horizontal facial growth pattern.

Fig. 25.—Horizontal and vertical facial growth pattern.

Fig. 26.—Vertical facial growth pattern.

Fig. 27.—Orthodontic treatment for three years failed to produce a desirable result (47 tracing to 50 tracing). For one year (from 50 tracing to 51 tracing), with orthodontic appliances still in place, tremendous growth took place. The combination of orthodontic treatment and favorable growth resulted in a very desirable and stable finished case.

DENTAL AREA

Being dependent upon the muscular and facial skeletal patterns, among others, the dental area is subject to endless variation. The following are of clinical interest.

1. Molar relation—Class I, II, or III.
2. Arch form—square to tapered.
3. Tooth size—maxillary teeth too small for mandibular teeth, and vice versa.
4. Arch length—crowding to spaces.
5. Inclination of incisors—vertical to severely tipped.
6. Overbite—deep to open-bite.

Fig. 28.—A sudden horizontal growth spurt occurring after orthodontic treatment.

Combinations of these factors, including only Class II molar relation cases, result in more than 300 distinct types of malocclusion. Is it any wonder that research on the dental area has been so prolific but so unsuccessful?

Clinical experience has shown us the following.

1. Extensive arch expansion is usually not successful.
2. Actual distal movement of molars is difficult.
3. Bodily movement is difficult.
4. Depression of teeth is extremely difficult, if achieved at all.

These factors, among others, limit the mechanical possibilities of treatment greatly and result in a need for more extensive and accurate diagnosis.

Diagnosis might be summed up in the following major steps.

1. Determine facial skeletal pattern.
2. Balance the maxillary and mandibular incisors to the skeletal pattern, keeping esthetics foremost in mind.
3. Determine as accurately as possible the contributions of the muscle pattern to the dental area.
4. Predict as well as possible the growth factors.
5. Last, by means of model analysis, determine what arch length and molar relation will result after consideration of these factors and the realization of the limitations of tooth movement.

It is helpful to remember that each individual tooth in the malocclusion at hand is probably in balance and harmony with the forces surrounding it. Our problem is to produce, by dental manipulation, bimaxillary arch balance and harmony, with pleasing esthetics within the confines of a fairly specific and dominant neuromuscular and facial skeletal pattern.

I realize that it is probably not apropos to touch on personalities at this time, but it does help to organize, in a general way, the material presented.

There are three orthodontists I admire very much—all very fine gentlemen, easy to talk to, and especially kind and helpful to the struggling neophytes in orthodontics, of which I am one. They all have many fine traits and qualities, but in my mind each represents a specific quality that makes orthodontics what it is today.

Dr. Cope Sheldon looks and acts like a fine orthodontist should look and act; Dr. John R. Thompson can speak on many of our orthodontic problems with confidence and understanding; and Dr. Wendell Wylie can write on orthodontic topics with intelligence and wit.

In addition, they represent the three approaches to orthodontic diagnosis: clinical sense and experience, practical clinical research, and more abstract clinical research.

By acting like men of science, speaking like men of science, and writing like men of science, we can keep the roads of clinical experience, clinical research, and basic research open for an ever-improving understanding of practical orthodontic diagnosis.

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A RATIONAL APPROACH TO THE TREATMENT OF THE MIXED DENTITION

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TREATMENT of the mixed dentition has suffered for many years as a result of the refusal of many orthodontists to realize the limitations of therapy as it is available to us. On the other hand, there has been a neglect of the possibilities of adequately applied treatment by many men who have avoided too completely the area of effective treatment of this same problem. A review of the background upon which our work should be based provides us with a firm foundation for the present-day treatment and an area in which, through changing methods, we may enlarge our effective applications of therapy.

Too often the arguments for early treatment are based upon the fallacious reasoning that corrected occlusal relations will insure proper function; that normal interrelation of the occlusion will result in functional stimulation sufficient to insure a normal growth and development of the various parts of the "oral mechanism." Such a view fails to account for environmental and hereditary influences which are not affected by the function that a civilized diet and environment provide. The anthropologic evidence shows that in the white race, and possibly in the Mongoloids and the Negroids there is a long-standing and deep evolutionary trend toward reduction of the bony structure of the face and diminution in size of the dental arches and the teeth themselves. Modern malocclusion seems to be encouraged, if not actually caused, by defective and arrested growth referable to improper diets, pathologic conditions of the nose and throat, and generally poor health that affects the entire organism.[1] Normal functional relationships do not mean adequate function, though they do provide the base upon which normal function can be established. Too often, too, restorations of occlusions to a theoretical ideal leaves out of account the hereditary environment which at least created the base of the problem which presents itself.

Hughes,[2] at Michigan, has this to say: "Investigation of several attributes of the dentofacial complex has revealed the extensive operation of hereditary factors which contribute to the formation of *normal* occlusion and malocclusion. Development or growth is an unfolding design of interrelated morphological and functional items."

We must remember that although genetic variability is fixed at conception, the nurtural variability is subsequently applied and the genetic con-

This paper was prepared in partial fulfillment of the requirements for certification by the American Board of Orthodontics.

tribution to individual variability not only is precedent in time but appears to exercise marked control over any nurtural and environmental circumstances which are instituted to modify that individual.

Moore and Hughes, from a study of seventy-eight families (265 individuals) derived the following conclusion: dentofacial deformity is, in most instances, a disorder characterized by hereditary deficiencies in osseous structures supporting the teeth.[3]

This point of view is buttressed by the findings of Krogman,[4] who finds a definite genetic basis for each individual dentofacial growth pattern, that these patterns tend to run in family lines. (The family line pattern, of course, will be made up from the contribution of genetic traits or units from each parent.) The resulting combination may produce an actual intradental, interdental, or dentofacial disharmony or a harmonious complex. In any case, the inherited pattern may be modified by one or more environmental factors. While research in the fields of anthropology and heredity constantly tends to stress the continuing patterns of the race in each individual, all of the findings indicate an important and variable effect through the operation of the environment.

One should examine with care the limitations imposed upon treatment by a purely mechanical outlook, as it has been proved without doubt that adequate function can affect growth. A splendidly managed scientific study was made by Watt and Williams[5] which should cause a definite re-evaluation of so much rigid theorizing and opinion in orthodontics. It was concluded that: "Function as influenced by differences in physical consistency of food is an important factor in growth and development of the mandible and maxilla of the rat. And, furthermore, while the inherent genetic factors concerned in the development of jaws are extremely important, the influence that masticatory function has in the growth and development of the jaws seems to be of real significance." Equally so, inadequate or perverted function, too, can affect growth and development, as in muscular habits—finger-sucking,[6] tongue-sucking, lip-biting, and perverted swallowing.

In addition, those factors that are capable of operating in specific growth sites (congenital stigmata, accidents, diseases, surgery) may and do arrest growth of only one part and hence bring about distortion of the growth pattern.[7-9] The problem before the present-day orthodontist is not only the restoration of normal dental relationships (which we can generally accomplish) but the replacement of inadequate environmental situations with more adequate ones. Normal occlusion is not enough to insure adequate function.

Waugh,[10] Williams,[11] and other observers of other primitive races all tend to show that primitive people possessed very efficient and healthy dentitions. Their dental arches were broad and well developed, the supporting bone was massive and dense, and the teeth were regularly arranged. Hooton,[12] too, says that the retrogressive changes in facial development are closely associated with the advance of so-called civilization and that any of the groups of racial stocks which have remained isolated and have continued to live under relatively

primitive conditions are likely to show diminished degenerative changes of the face or often none at all. The rapidity with which changing environmental conditions can change the hereditary patterns of these isolated racial stocks leads us to conclude that any too-rigid adherence to superficially similar hereditary human patterns as a limiting factor in orthodontics is likely to close off for us large areas of investigation and treatment through environmental manipulation.

It is only with presently slightly explored and almost neglected techniques that we will be able to apply the effects of adequate function. Better nutrition (in terms of quality, texture, and distribution), better mental hygiene affecting the production and the prevention of neurotic habits, such as finger-sucking, tongue-sucking, nail-biting, and perverted swallowing. It is through such areas of prevention and in functional retraining that we shall look into the future to more adequate techniques. It would seem that all the proof piled up in the last generation as to the effects and inadequacies of orthodontic technique points directly only to the effects of mechanical therapy applied to the teeth.

Brodie[13, 14] followed his reports on the consistency of developmental patterns with the proof that those patterns change with special circumstances. Wylie has indicated, too, that continued perversion of swallowing will affect the gonial angle with resultant change of morphologic patterns. We have seen that the environment begins to work on the hereditary pattern from the instant of birth, and the most immediate and constant factor in the environment is the musculature that supports and surrounds the teeth. This musculature has great powers of adaptability and habit formation and, if the skeletal pattern is anything but normal, the musculature tends to perpetuate it by adapting itself to the abnormal pattern. All subsequent alveolar growth, as well as eruption of the teeth, is likely to be forced into conformity with this disturbed function.[15] This need to correct and change these muscular patterns is one of the greatest factors in the need for early and effective treatment. All treatment of the mixed dentition should be aimed at correcting the distortions of the muscular environment with their effects on the mature dentition and face, which all too often cannot be corrected.

The interdependence of structure and function is one of the fundamental laws of biology. The structure of a bone under both normal and pathologic conditions is dependent upon its function. The latter does not play any role in the first stages of development of a bone, but the final shaping of a skeletal element and the final elaboration of its internal structure occur only under the influence of normal function. Wherever the mechanical conditions of a bone have been investigated thoroughly, the close correlation of structure and function has been fully established.[16] Within limits of tolerance, an increase of the normal forces of pressure or tension leads to formation of new bone.[17] Pressure on growing bone leads to change in form, and pressure on mature bone leads to change in structure.

We have seen that we are dealing with a complex anatomic grouping which follows in its own manner the same laws that govern the rest of the

body. The bone, muscle, and teeth which constitute the dentofacial complex have no laws of development other than those which govern the rest of the body. Hereditary patterns, good or bad, are but a foundation upon which Nurture and environment work their influence from the moment of conception. The bone of the jaws is as the bone of the rest of the body. Functional stresses shape the bones, and change in the strength or direction of forces will lead to changes in the form and structure of bones.[18]

Having evaluated the background from which we develop our therapy, let us look into the areas in which no controversy exists in the treatment of the mixed dentition:

All cross-bites, anterior and posterior.
All malocclusions associated with oral habits (thumb, tongue, and lips).
Deep anterior overbites.
All cases of drifting of permanent teeth as a result of loss, or loss of dimension of, primary teeth.
Imminent transpositions of permanent incisors, canines, and premolars.
Irregularities caused by the presence of supernumerary teeth.
Ectopic eruption situations, particularly of the first molars.

It will be noted that these fall into two general classes. The first group all have definite perverted functional and muscular effects; the second, and rather minor, group represents the more purely local disturbances of single tooth position.

It is in these two general groups that successful, rewarding treatment of the mixed dentition is available with little chance of failure. But this leaves us with two of the larger problems of modern orthodontics untouched: the distoclusion problem and the problem of crowded dentitions, mostly in neutroclusion. It is in both of these groups that an awareness of the limitations of treatment leads us to a most rewarding result in therapy. When the orthodontist is willing to concede that at the present moment of treatment we are dealing with an end result of evolutionary, environmental, and genetic factors and a pathology of the masticatory apparatus which is but an index of the biologic state of the whole human organism and, also, that our present therapies are largely limited to changing only the most superficial aspects of that pathology (the alveolar bone and the tooth relationships therein[19]), then we can accomplish effective therapy.

We feel that it is of value on many levels to treat Class II, Division 1 cases that present in the early mixed dentition, with the restoration of normal lip function, with better possibility of normal breathing, swallowing, and speech as immediate and apparent gains. The prevention of psychic maladjustment as a result of deformity is another frequent gain, as is removal of the inhibitory effects of perverted muscular function on the active growth center of the condylar head (which center can be inhibited by excess pressure).[20] The retrusion of the upper anteriors and their protection by the lips (against accident) is another immediate gain.

The great problem of treatment of distoclusion cases in the mixed dentition is that of anchorage, and the use of cervical straps or occipital caps with labial arches to the maxillary arch provide a means of applying adequate force without creating a procumbency of the too-easily disturbed axial inclinations of the lower anterior teeth.

It is not to be expected that the treatment of the Class II case in the mixed dentition will always result in a perfect mature dentition, but the immediate gains of normal facial function and form would be sufficient reason for treatment if no further improvement were effected upon the dentition, but such is not the case, as many cases will remain stable and essentially normal following the transition into the permanent dentition.

The problem of the crowded lower arch presents an even greater chance for aid and prevention, and it is here that a working base for determining when and when not to reduce tooth structure to harmonize with the quantity of bone Nature has provided is necessary. We have found that a simple and practical procedure for determining the correlation between tooth size and arch dimension is that recommended by Carey of Palo Alto.[21] Accepting the premise of Nance[22] that there is an inevitable drift of the lower first molars of approximately 1.7 mm. on each side with shift from the mixed to the mature dentition, we add this total to the width of the premolars and canines which we determine from the correlation of x-rays and a scale derived from the measurements of Ballard and Wylie[23] (Fig. 1), and to this by direct measurement the sum total of the width of the anterior teeth. When we find that the total width of these teeth is not more than 2.5 mm. greater than the arch length as measured from the mesial of the first molar to the mesial of the first molar along the buccal cusps of molars and centering over the ridge in the incisal region, then we feel that treatment toward a normal occlusion with a full complement of teeth is indicated and justified, provided, too, that the familial indications (as can be ascertained from the occlusions of the immediate relatives) tend to indicate a relatively normal hereditary pattern, and treatment should be started in the mixed dentition as early as possible. When the discrepancy is greater than 2.5 mm. but less than 5 mm. and we are not dealing with conditions of abnormal drifting or cross-bites, or lingual version of the lower anteriors, we are hesitant about instigating any but palliative treatment for maintenance of arch length and extraction of deciduous canines to allow the correction of the anterior alignment. It is in the borderline cases, which lie between a discrepancy of 2.5 mm. and 5 mm., that the most acute judgment of the operator comes into play. Here we also must evaluate most carefully the cephalometric analysis of the skeletal pattern to determine the possibilities that the basal bone structure has to offer in support of a seemingly too great amount of tooth structure. The closer to the Downs normals[24] the evaluation, the less likely the need for extraction, although the possibility of treatment without some relapse is doubtful. The end result should be adequate without extraction, particularly if treatment is early and adequate function can be achieved through exercise and vigorous chewing. Here, most particularly, we

should examine the family pattern as a rough indication, of the possibilities of treatment. When the discrepancy is greater than 5 mm., we proceed to extract the upper and lower primary canines and after the alignment of the anteriors has taken place, we try to insure the early eruption of the first premolar teeth (through the extraction of the first primary molars when necessary) so that the first premolars may be extracted before the eruption of the canine teeth, provided that the second premolars are present, well formed, and of good size. In this manner, a severe malocclusion can be avoided and a simple situation evolves in the final dentition, which lends itself to easy

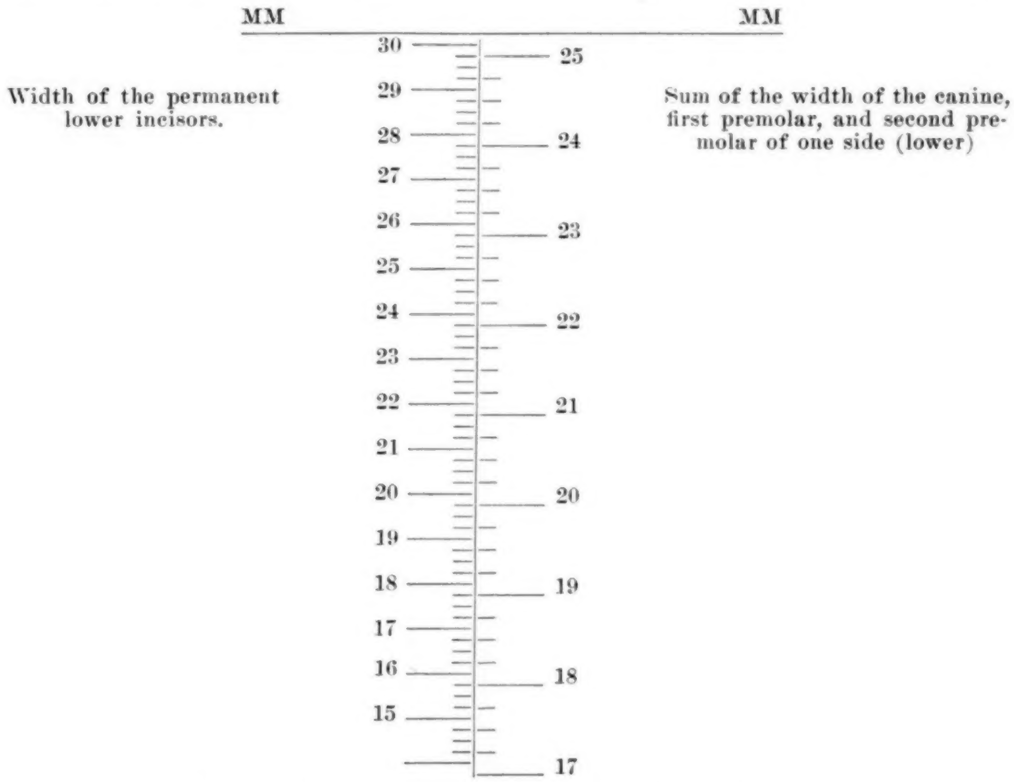

Fig. 1.—Scale of Wylie and Ballard, expressing the correlation of size between the permanent lower incisors and the permanent lower canines and premolars.

manipulation. One does not come to the decision to extract premolar teeth in the early dentition without a great deal of thought, but in the absence of mitigating circumstances such as mesial drifting of molars, cross-bites, or lingual inclination of lower anteriors as a result of a deep overbite. The decision to extract in those cases where the linear arch dimension shows a discrepancy greater than 5 mm. for the positioning of the permanent teeth is based on the experience that a case where such discrepancy exists will not maintain itself without severe relapse when all retention is removed. The early extraction of the primary canine teeth shows no untoward effect on the growth of the jaws.[25] Weinman and Sicher tell us that the assumption that the presence of teeth in proper number and relation is necessary for the normal growth of the jawbones is erroneous, and that only the alveolar process is

dependent upon the presence of teeth. The gratifying reward is the alleviation of a severe malocclusion with simple therapy. The aborting of a severe malocclusion which can no longer be prevented is a rewarding procedure. We can eliminate from practice the frequent high canine cases and invariably avert impaction of these same teeth in the crowded arch. Retraction of protruding teeth and alignment of the anteriors are easily accomplished in these cases, which then can be retained with a lower lingual arch and upper Hawley type retainers, which also can be used to correct any existing discrepancy of the overbite. The early extraction of the first deciduous molars usually (but not always) will insure the precedence of the first premolars over the canines in eruption, at which time they can be removed and the retention continued until the eruption of the canines and second premolars, when final corrections can be made.

All of these procedures have the great advantage of restoring to the patient the possibilities of normal function of the oral musculature with the better chance for restoration of more nearly normal function to those parts and the development of more normal facies, if the skeletal pattern of these patients present favorable measurements in terms of the Frankfort-mandibular plane angle and more particularly the Downs cephalometric normals.[26, 27] Early restoration of normal muscular function eventually will help in the development of a pleasing facial appearance with the concomitant effect of avoiding the psychic maladjustment that is almost inevitable in the adolescent with a severe malocclusion. While the appearance of the face is influenced by the morphology of the facial skeleton and the relationship of the jaws, it must not be forgotten that the muscles, skin, and other soft tissues play an important part in the establishment of facial contours.[28] Early treatment presents us with our greatest opportunity to allow those tissues to assume their optional function through the removal of any abnormal stresses and function placed upon them by a malformed denture.

The muscles should be given a particular amount of attention and every effort must be made to attain, as quickly as possible, the condition known as tonus. During growth, the muscles have not been strong enough to overcome the interferences of the occlusion. When the interferences are removed through mechanical treatment, we then may strengthen the various muscular groups and thus assist in the establishing of a normal oral mechanism which can function in a smooth and harmonious manner.[29] It is wise, in addition to having created a base for normal function, to apply corrective exercises to those areas that have suffered from malfunctioning. In these instances, the exercises described by Rogers[30] provide our most effective regime.

Let us realize that at this time we are beset with limitations in our treatment situations, but that we have not, in any real sense, explored more than the fringes of the possibilities inherent in nurture and environmental control and their probable effects upon the problems of facial malformation. The defects imposed upon us by civilization are not inviolable, and with time and effort they will lend themselves to our control. Orthodontics today is mechanically efficient and physiologically immature. If we are to progress,

we must not let mechanics be our sole goal or our end. The prevention of dental and facial deformities is an infinitely greater and more difficult goal to attain. We must not let mechanical facility obscure our real goal, which is a healthy, well-adjusted oral mechanism in a healthy patient.

SUMMARY

1. There is anthropologic proof that malocclusion is a part of deep-rooted evolutionary elements tending toward a reduction of facial structure.

2. There are extensive hereditary factors working on the formation of the dentofacial complex.

3. The interrelationship of hereditary and environmental factors creates the individual, but the hereditary factors take precedence over the environmental factors.

4. Through the experimental evidence compiled on rats and through observations of primitive peoples, we can be sure that function plays a large part in the growth and development of the jaws.

5. Early treatment of the mixed dentition, which tends to create the conditions for normal function, is useful in procuring a beneficial effect upon the growth and development of the patient's dentofacial complex.

6. In those cases which, through measurements, show a definite deficiency of basal bone beyond the scope of present-day techniques to remedy, early serial extraction of primary canines and first primary molars followed by extraction of the permanent first premolars upon their eruption can abort the production of a severe malocclusion.

7. Even when treatment must be reinstated in the permanent dentition, the early re-creation of normal function has a beneficial effect in terms of better balance of the facial structures.

8. An awareness of the limitations imposed upon treatment by heredity, environment, nurture, and present-day techniques will result in more effective and efficient treatment.

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ROOT RESORPTION IN HUMAN PERMANENT TEETH

A Roentgenographic Study

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INTRODUCTION

Resorption of the roots of primary teeth is a normal phenomenon. Although one of the important factors responsible for the resorption of the roots of primary teeth is the presence of a permanent successor, root resorption may occur even when a permanent successor is absent.[16, 17, 21] The resorption potential of the primary teeth, therefore, is high in contrast to the permanent teeth whose roots show marked resorptions only under special circumstances, such as trauma, infection, orthodontic tooth movement, and in certain systemic diseases.[25, 3] Thus, there appears to be an inherent predisposition for the roots of all teeth, permanent as well as primary, to incur resorptions, albeit to greatly varying degrees.

It was the purpose of this investigation to study the resorption potential in human permanent teeth by analyzing the frequency and the degree of root resorption as revealed by routine intraoral roentgenograms of "normal" and orthodontically treated teeth.

REVIEW OF THE LITERATURE

The resorption of permanent teeth was first mentioned by Bates, in 1856, when he stated the cause to be the traumatization of the periodontal membrane (that is, by a blow).[1] Following the publication of this report, numerous case reports of root resorption in permanent teeth appeared in the literature. However, these reports described only the severe and bizarre types of root resorptions and added little to the fund of knowledge concerning the frequency or the distribution of "normal" root resorption in permanent teeth.

Prior to the appearance of reports by Ketcham in 1927 and 1929,[18-20] little attention was paid to root resorptions as a normal phenomenon in permanent teeth. Ketcham indicated that 21 per cent of 500 patients whose teeth were examined roentgenographically after orthodontic treatment showed distinct evidence of root resorption of the permanent teeth. He stated, incidentally, that

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**This paper was part of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Pedodontics in the Graduate College of the University of Illinois in 1951.

root resorption occurred in only 1 per cent of the persons not subjected to orthodontic therapy. However, it is fairly certain that Ketcham reported only instances of very obvious resorptions as evidenced by marked foreshortening of the roots. It also might be noted that roentgenographic techniques were not yet standardized at that time, so that well-angulated, undistorted, and clear films, such as are routinely available today, were a rarity in 1929.

In 1936, Rudolph[29] reported that the incidence of root resorption in permanent teeth was as high as 74 per cent during or following orthodontic therapy. Later he showed an even higher frequency of root resorption (100 per cent).[30] A similar age group (7 to 21 years) that had not been treated orthodontically was compared with the orthodontically treated group. He reported that only 5 per cent of the control group showed root resorptions. Here again it is evident that Rudolph reported only obvious foreshortening of the roots, although this is not stated in his paper.

Becks observed that excessive orthodontic forces did not cause any changes of the root surface in certain patients, while moderate forces sometimes produced tremendous amounts of root resorption in others.[3] From earlier animal experiments (1931), Becks felt that a certain amount of the resorptions in permanent teeth observed after orthodontic treatment was not due directly to the orthodontic treatment itself but was due primarily to concurrent metabolic upsets. Accordingly, in 1936 Becks studied 100 patients with roentgenographically obvious root resorptions. One-half of the group had previous orthodontic treatment and the other half did not. He found that only 20 per cent of the persons who had undergone orthodontic treatment incurred root resorption due to the mechanical trauma incident to tooth movement. This was confirmed by the patients or the orthodontists. The rest of the resorptions (80 per cent) were due to systemic factors as diagnosed by changes in other osseous structures.

In a subsequent study (1939), Becks obtained roentgenograms of a group of seventy-two patients before the beginning of orthodontic treatment and again after orthodontic therapy had been in progress for a period of six months. Definite root resorptions were found in 32 per cent of the individuals before the beginning of orthodontic treatment. During the course of orthodontic management, the frequency of root resorption increased to 73.6 per cent.

Becks concluded from these studies that orthodontic therapy was not the sole factor in the production of root resorption in these patients. He stated that certain patients have a predisposition to root resorption, and in these orthodontic treatment will cause excessive root resorptions, while those who do not have this predisposition will not be affected.

In 1947, at the University of Illinois College of Dentistry, a plan was formulated to analyze the prevalence and the mechanism of root resorption in permanent teeth. One part of this plan was to attack the problem histologically, and therefore, a quantitative analysis of the resorption pattern of cementum of permanent teeth was made by Henry and Weinmann in terms of the number, size, distribution, and types of resorption areas.[15] They found

that 90.5 per cent of the 261 teeth examined histologically showed areas of resorption. They also found that, contrary to the views held by earlier investigators, inflammation, per se, did not cause resorption. They showed that there was little or no resorption of cementum in the gingival third of the root, although gingival and periodontal inflammation and pockets were common in this region. The greatest number of resorptions (76.8 per cent of the total) occurred at the apex of the root where no inflammatory changes could be seen. They noted incidentally that, under ideal conditions, relatively small areas of resorption could be seen in the original roentgenograms taken of the intact teeth, if one looked for them carefully.

Summary.—From a review of the literature, it becomes evident that the resorption of permanent tooth roots is not uncommon. The most obvious causes of root resorptions in permanent teeth are infection, trauma, and orthodontic tooth movement. However, resorption of the roots of permanent teeth frequently occurs in the absence of these agents. This points toward an innate predisposition to resorption in permanent (as well as primary) teeth. The evidence also shows that this resorption potential varies in different individuals. In some cases, the teeth appear to be extremely susceptible to root resorptions so that severe resorptions occur, even in the absence of any demonstrable causes. In others, the teeth appear to be very resistant to resorptions so that roots remain intact even after severe trauma or extensive orthodontic movements.

This investigation was designed to measure the resorption potential of permanent teeth by analyzing the frequency and severity of root resorptions as revealed by routine intraoral roentgenograms.

MATERIALS AND METHODS

Materials.—The first portion of this study was based on the analysis of 708 sets of roentgenograms of complete dentitions, containing a total of 13,263 permanent teeth. The patients ranged in age from 12 to 49 years. None had undergone orthodontic therapy.

The second portion of this study involved the examination and analysis of full-mouth roentgenograms of eighty-one patients who had undergone orthodontic treatment in the Department of Orthodontia. These patients ranged from 12 to 19 years of age.

Method of Examination.—Each film was carefully examined by transmitted light using a binocular loupe with a 3× magnification This detail is important, since superficial examination will not reveal the presence of very mild and mild resorptions on the surface of the tooth roots. Binocular vision and at least 3× magnification are essential to the discovery of minute areas of resorption. A large magnifying lens (×3) also may be used if time and care are taken in the examination of each film.

In every instance, each tooth root was examined in two films and, therefore, from two different views. Where only one film and one view of a par-

ticular tooth root were available and the resorptions could not be seen clearly, the film was discarded and the tooth recorded as "not diagnosable."

Method of Assessment.—The amount of periapical root resorption in the roentgenogram of each tooth was assessed in the following manner (see also Fig. 1):

Degree or Type of Resorption	*Description*
0	No evidence of resorption.
?	Resorption questionable. Root outline intact but there appear to be minute areas of spotty resorption. Lamina dura is interrupted and the periodontal membrane widened.
1+	Root apex definitely blunted and resorbed for at least 1 mm. to about 2 mm. Lamina dura interrupted and periodontal membrane widened about the periapical area of the root.
2+	Resorption of root apex for at least 2 mm. to 4 mm. Lamina dura interrupted and periodontal membrane widened.
3+	Resorption of root 4 mm. to one-half the root length.
4+	More than one-half the root resorbed.
#5	Root resorption definitely related to root canal therapy (degree not assessed).
#6	Root resorption definitely related to periapical infection (cysts, etc.).
8	Not diagnosable (roentgenogram of poor quality).
9	Tooth missing.

The method of rating the amount of root resorption was similar to, but more detailed than, the one employed by Hemley[14] during his analysis of root resorptions caused by different types of orthodontic tooth movements.

Since all data were punched on IBM cards and analyzed from machine tabulations, the numerical system was employed.

FINDINGS

Prevalence of Root Resorption.—Of the 708 persons (ages 12 to 49) whose teeth were carefully examined roentgenographically by means of binocular loupes at a magnification of 3×, 100 per cent showed some degree of apical root resorption in one or more teeth.

Of the 13,263 teeth examined roentgenographically in the same manner, 86.4 per cent showed definite evidence of some degree of resorption (1+ or more). Only 209 teeth (1.6 per cent) showed no evidence of apical resorptions and the remaining 12 per cent were scored as having questionable resorption (Fig. 2).

Average Number of Resorbed Teeth per Person.—The average number of permanent teeth resorbed per person was sixteen. A frequency distribution

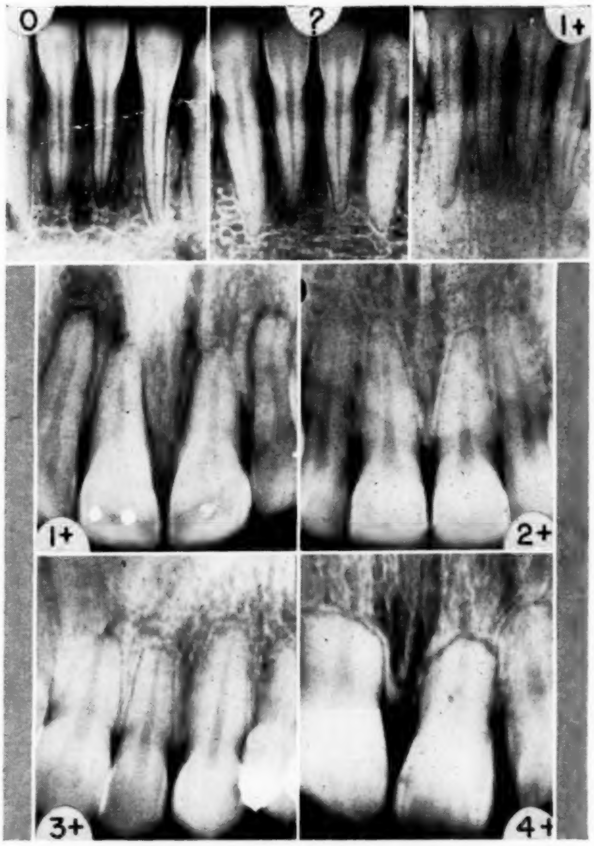

Fig. 1.—Roentgenograms illustrating teeth with no root resorption (*O*), questionable resorption (*?*) and with mild (*1+*), moderate (*2+*) and severe (*3+* and *4+*) degrees of root resorption. See text for detailed description of the characteristics of each category.

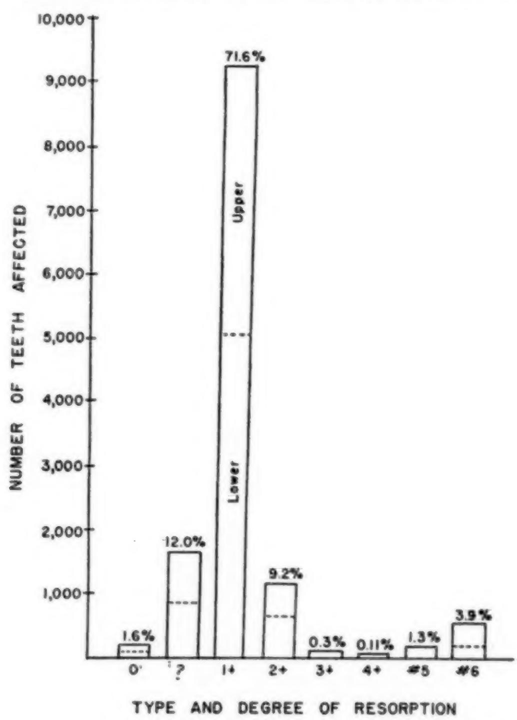

Fig. 2.—Distribution of teeth according to type and degree of periapical resorption. (For definition of types and degrees of resorptions see Fig. 1.)

of the data showed that this average was a true central tendency (Fig. 3). These findings indicate that the resorption of permanent teeth is far more prevalent than previously reported.

Sex Differences.—Slight differences were apparent between the sexes in the number of persons and in the number of teeth affected. However, statistical testing indicated that in this series the differences were not significant. Therefore, in subsequent analyses the teeth of both sexes were combined.

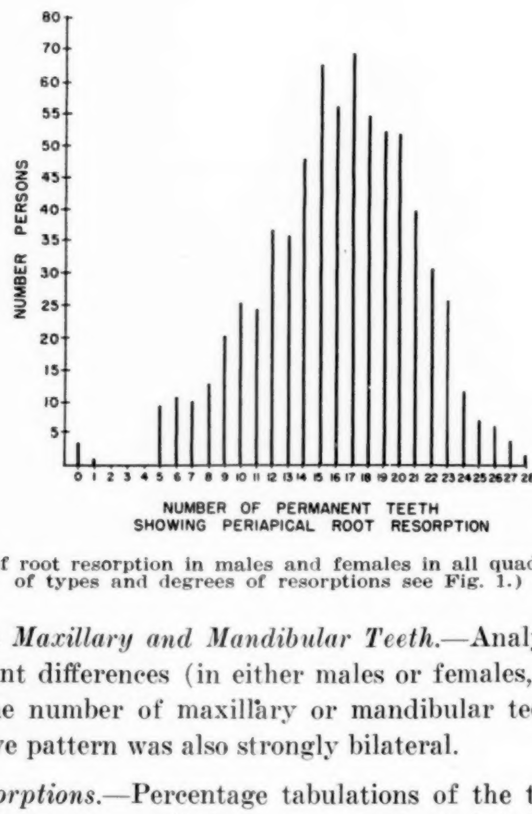

Fig. 3.—Comparison of root resorption in males and females in all quadrants. (For definition of types and degrees of resorptions see Fig. 1.)

Differences in Maxillary and Mandibular Teeth.—Analysis of the data revealed no significant differences (in either males or females, separately or combined) between the number of maxillary or mandibular teeth affected (Table II). The resorptive pattern was also strongly bilateral.

Types of Resorptions.—Percentage tabulations of the types of resorption revealed that faulty root canal therapy or periapical infections (# 5 and # 6) accounted for only 5.2 per cent of the resorbed roots of teeth (Table I). In 81.2 per cent of the teeth no apparent cause for the root resorption could be discovered (Table I).

Severity of Resorption.—Approximately 71 per cent of the teeth examined showed only slight (1+) resorptions. These could be detected only after careful study of each roentgenogram. However, 9.2 per cent of the teeth examined showed moderate degrees (2+) of resorption, which were easily and readily visible to the naked eye. A small number of teeth (0.41 per cent) were found to have unusual amounts (3+ or 4+) root resorption. These could hardly be missed, even during cursory examination.

From these data, it may be concluded that it is "normal" for permanent teeth to incur some slight degree of resorption (1+) during their life span.

TABLE I. DISTRIBUTION OF ROOT RESORPTIONS IN 6,280 MAXILLARY AND 6,983 MANDIBULAR TEETH

TYPE AND DEGREE OF RESORPTION*	PER CENT OF TEETH AFFECTED		
	MAXILLARY	MANDIBULAR	COMBINED
0	1.79	1.37	1.58
?	12.1	11.8	11.98
1+	70.98	72.1	71.61
2+	7.8	10.3	9.19
3+	0.33	0.27	0.30
4+	0.12	0.08	0.11
#5	1.78	0.85	1.29
#6	5.03	2.96	3.94

*0 —No evidence of resorption.
? —Questionable resorption.
1+—Root resorbed for at least 1 mm. to 2 mm.
2+—Root resorbed for at least 2 mm. to 4 mm.
3+—Root resorbed for at least 4 mm. to one-fourth of root length.
4+—Root resorbed more than one-fourth of root length.
#5 —Root resorption related to root-canal therapy.
#6 —Root resorption related to periapical infection.

In this sample, almost 10 per cent of the teeth showed obvious amounts of root resorption (more than 2 mm. of root length) without any apparent cause. This indicates that, while the resorptive potential of the permanent teeth is fairly low in the majority of cases, it can be expected to be fairly high in approximately 10 per cent of the teeth examined.

Susceptibility of Individual Teeth to Resorption.—The susceptibility of the individual classes of teeth to the various types and degrees of resorptions were then analyzed. It was found that the lower anterior teeth were most susceptible to idiopathic resorption, followed closely by the upper lateral incisors (Table II). The next most susceptible group was made up of the premolars, the upper central incisor, and upper canine. The least susceptible group was composed of the upper and lower first and second molar teeth. The order of susceptibility of teeth to resorption in this study differs very

TABLE II. DISTRIBUTION OF 13,263 TEETH EXAMINED ACCORDING TO DEGREE OF RESORPTION

DEGREE OF RESORPTION	PER CENT OF TEETH AFFECTED						
4+	0.3	0.2	0.1	0.1	0	0	0
3+	0.7	0.3	0.3	0.2	0.3	0.2	0
2+	7.6	10.3	6.2	7.6	5.7	10.2	6.2
1+	68.1	74.4	72.4	73.4	73.2	65.6	64.2
?	15.2	7.8	14.7	9.5	12.9	11.1	15.7
0	2.3	1.0	2.1	0.96	1.7	2.4	2.9
Number of maxillary teeth examined	1111	1083	899	1039	991	788	369
Tooth class	1	2	3	4	5	6	7
Number of mandibular teeth examined	1196	1027	1001	1052	1031	754	822
0	0.41	1.07	1.3	1.3	2.1	2.1	1.5
?	2.9	12.0	11.7	11.1	15.5	17.1	16.3
1+	78.5	76.8	77.8	74.0	69.7	57.1	64.3
2+	17.0	9.2	8.2	10.3	6.6	10.7	9.1
3+	0.3	0.1	0.1	0.2	0.3	0.1	0.5
4+	0	0	0	0.1	0.1	0.1	0

Data were tested for bilaterality. No significant differences between the right and left sides were observed.

little from the order of susceptibility of teeth as reported by Becks,[3] Rudolph,[30] and Hemley.[14] These findings indicate that the resorptive potential is not the same for all permanent teeth, but is higher in some (lower anteriors and upper premolars) and lower in others (molars), even in the same individual.

TABLE III. INCIDENCE OF MILD (1+) AND MODERATE (2+) DEGREES OF RESORPTION IN PERSONS 12 TO 49 YEARS OF AGE

AGE GROUP	NUMBER OF TEETH EXAMINED	PER CENT OF TEETH WITH 1+ RESORPTIONS	PER CENT OF TEETH WITH 2+ RESORPTIONS
12 to 15	972	62.6	4.0
16 to 19	987	67.1	7.4
20 to 24	362	73.8	9.1
25 to 29	2625	74.9	5.4
30 to 34	1815	68.4	13.0
35 to 39	1302	81.7	2.6
40 to 44	891	71.4	8.7
45 to 49	1009	60.1	27.6

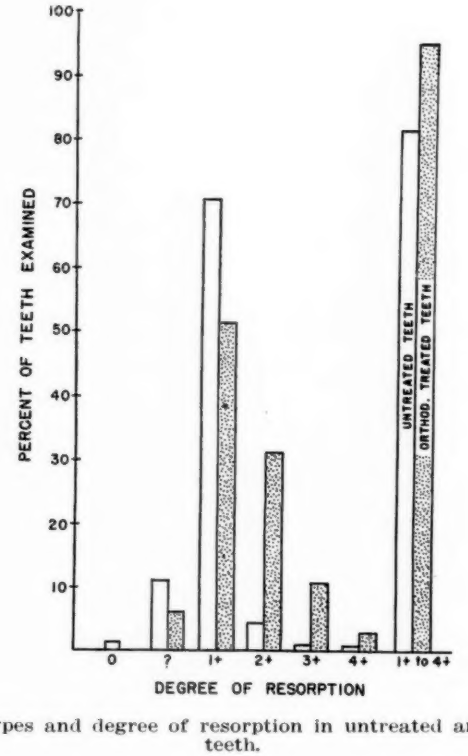

Fig. 4.—Comparison of types and degree of resorption in untreated and orthodontically treated teeth.

Incidence of Periapical Resorption—There did not appear to be any significant increase or decrease in mild resorption experience with age within this group (Table III). However, there did appear to be a significant increase in the frequency of the more severe (2+) degrees of resorptions with age (Table III).

ROOT RESORPTIONS IN ORTHODONTIC PATIENTS

Orthodontic procedures seem to constitute a form of "experimental" procedure which brings to more complete expression the inherent resorptive potential resident within the teeth of a given person. Therefore, it was felt that analysis of the roentgenograms taken after orthodontic treatment might reveal details in the resorptive pattern not revealed in the untreated patients. Eighty-one sets of posttreatment roentgenograms were obtained from the Department of Orthodontia through the courtesy of Dr. A. G. Brodie.

Careful study of these roentgenograms by means of binocular loupes at a magnification of 3× revealed that 93.3 per cent of 2,085 orthodontically treated teeth showed definite evidence of root resorption (1+ or more), while 6.7 per cent were assessed as having questionable resorption. In no instance could a tooth be diagnosed as having experienced no resorptions.

Severity of Resorption.—Although the number of teeth involved by resorptions was increased only slightly after orthodontic treatment (from 81.2 per cent to 93.3 per cent of the teeth examined), the severity of these resorptions was very obviously and markedly increased (Tables IV and V). It was found that the frequency of moderate degrees (2+) of resorptions rose from 9.2 per cent in the untreated control group to 31.4 per cent in the group treated orthodontically (Fig. 4). Severe (3+) resorptions increased from 0.3 per cent in the untreated group to 10.8 per cent after orthodontic treatment, while very severe (4+) resorptions rose from 0.11 per cent to 3.4 per cent of the teeth.

TABLE IV. DISTRIBUTION OF VARIOUS DEGREES OF ROOT RESORPTION IN EIGHTY-ONE ORTHODONTIC PATIENTS*

DEGREE OF RESORPTION	PER CENT OF TEETH AFFECTED						
4+	12.4	7.6	0.0	1.8	0.0	0.0	0.0
3+	30.7	40.3	3.8	3.6	0.0	0.0	0.0
2+	44.3	46.1	34.6	36.2	33.7	44.0	0.0
1+	12.4	5.7	61.5	58.1	64.2	54.0	64.7
?	0.0	0.0	0.0	1.8	1.9	2.0	35.2
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of maxillary teeth examined	169	156	156	160	154	150	102
Tooth class	1	2	3	4	5	6	7
Number of mandibular teeth examined	168	168	135	156	153	150	108
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
?	0.0	0.0	6.6	11.5	5.8	6.0	47.2
1+	3.5	37.5	64.4	65.3	70.5	74.0	47.2
2+	37.5	46.4	24.4	23.0	21.5	20.0	5.5
3+	44.6	10.7	4.4	0.0	0.0	0.0	0.0
4+	14.2	5.3	0.0	0.0	1.9	0.0	0.0

*Compare with Table II.

These data indicate a marked increase in the prevalence and severity of apical root resorptions after orthodontic procedures and conform, in the main, with similar findings by other investigators.

Susceptibility of Individually Treated Teeth to Resorption.—Analysis revealed that those teeth which showed low or questionable resorptive activity

TABLE V. DISTRIBUTION OF ROOT RESORPTIONS IN 2,085 TEETH OF EIGHTY-ONE ORTHODONTIC PATIENTS (COMPARED WITH NONORTHODONTIC PATIENTS)

TYPE AND DEGREE OF RESORPTION	TEETH AFFECTED BY RESORPTION	
	ORTHODONTIC GROUP (PER CENT)	NONORTHODONTIC GROUP (PER CENT)
0	0.0	1.6
?	6.8	12.0
1+	47.6	71.6
2+	31.4	9.2
3+	10.8	0.3
4+	3.4	0.11
#5 and #6	0	5.2
	100.0	100.01

in the untreated group were apparently "stimulated" by orthodontic tooth movement to show definite but mild (1+) resorptions, while those teeth which were susceptible to only mild (1+) resorptions became more severely resorbed (2+, 3+, 4+) under the influence of these mechanical stresses. Those teeth which showed obvious root resorption before treatment tended to show very severe (3+ and 4+) amounts of root resorption after treatment. The following four groups of susceptible teeth can be distinguished.

Group I. Lower and upper anterior teeth (most susceptible).

Group II. Upper first molar, first and second premolars, and canine.

Group III. Lower canine, first and second premolars, and first molar.

Group IV. Upper and lower second molars (least susceptible).

This group showed again that the resorptive potential varied not only among different individuals, but also in a given individual among different groups of teeth.

Correlation Between the Amount of Root Resorption Before and After Orthodontic Procedures.—Seventy-six cases were available with full-mouth roentgenograms taken before, during, and after the completion of orthodontic (edgewise arch) treatment. These were analyzed to determine the correlation between the amount of root resorption evidenced roentgenographically before and after treatment. Even superficial review revealed that those children who showed the higher degrees of periapical resorptions before treatment suffered the greatest amounts of root resorption after treatment.

In only three instances were severe (3+) degrees or root resorptions seen after orthodontic treatment when the pretreatment roentgenograms showed very little periapical resorptions. In eight cases, the pretreatment roentgenograms showed sufficient amounts of periapical resorptions to rank these cases in the upper twentieth percentile. However, the roentgenograms taken after the completion of treatment were rated in the fiftieth percentile. Statistical analysis (using rank correlation methods) showed the correlation between pretreatment and posttreatment roentgenograms in this group of seventy-six cases to be +0.82. This high degree of correlation indicates that a valid prog-

nosis can be made by the clinician as to the amount of root resorption that could be expected in the majority of cases after orthodontic treatment on the basis of a careful analysis of the roentgenograms taken before treatment is instituted. This finding is in complete accord with findings obtained by Becks in 1939 in a similar analysis.[4]

When individual teeth (instead of persons) were analyzed as to the degree of root resorption evidenced before and after orthodontic treatment, an even higher degree of correlation could be achieved (+0.89). This was striking in a few cases in which the roots of one or two individual teeth (usually upper premolars) were very severely (4+) resorbed. Analysis of the pretreatment roentgenograms revealed that the resorption was already well advanced (2+) and the entire surface of the root strongly marked by resorption bays before treatment was instituted. These findings indicate that careful analysis of the roentgenograms taken before orthodontic treatment is instituted may enable the clinician to discover (a) the majority of cases in which root resorption may become extensive and severe during orthodontic treatment and (b) in a given case, those teeth most likely to suffer from unusual amounts of root resorption.

DISCUSSION

Comparison With Earlier Studies.—The prevalence (number of persons affected) of root resorption among "normal" subjects reported in this study is much higher than that previously reported for similar age groups by Ketcham (1 per cent), Rudolph (5 per cent), or Becks (32 per cent). This can be accounted for only by the fact that a much more diligent and careful search was made for minor degrees of root resorptions in this study with the aid of magnifying binocular loupes. It seems clear that previous investigators reported only the more obvious resorptions (2+ or more, as defined in this study) and did not report the more subtle and smaller periapical resorptions, which can be detected by careful study. This hypothesis is strongly supported by Henry and Weinmann who showed root resorptions in all teeth studied histologically.[15]

The Resorption Potential.—It apparently is normal for all teeth to incur some degree of mild (1+) resorption during their life span for reasons not apparent at this time. The term *idiopathic resorption,* therefore, seems appropriate. These resorptions are sufficiently large to be visible in a well-angulated and technically adequate roentgenogram. Apparently, these mild resorptions have little clinical significance. However, when a given dentition shows numerous teeth with more severe resorption (indicating a high resorption potential) this must be interpreted as a warning that the superposition of traumatic procedures (such as orthodontic treatment) might accelerate the process of resorption and cause the loss of a large portion of the root.

It seems clear that a given resorption potential is inherent within the tissues of a given individual. In the great majority of cases (72 per cent) this potential is "normal," that is, present to a slight (1+) degree. However, in approximately 9 to 10 per cent of persons and teeth, we may expect unusual amounts of idiopathic root resorption (2+ and 3+). After orthodontic proce-

dures, we may expect approximately 31 per cent of the patients and 31 per cent of the teeth to show moderate amounts (2+) of resorption. Approximately 14 per cent of the teeth can be expected to show one-fourth or more of the root length to be resorbed after orthodontic treatment. A large proportion (ten out of fourteen, or 77 per cent) of these instances can be detected by a careful analysis of the roentgenograms taken before treatment is instituted.

Etiology of Root Resorptions During Orthodontic Treatment.—The nature of this predisposition to root resorption is unknown. In fact, the real cause for the unusual degrees of marked resorptions of the roots seen in some cases after orthodontic treatment is also unknown. Marshall indicated that improper diet was the underlying cause, but he did not present convincing data.[25] Becks insisted that various systemic diseases, especially endocrinopathies, were the exciting factors in idiopathic root resorptions and were the underlying factors in cases showing marked degrees of orthodontic root resorption.[3, 4] He rated more than 50 per cent of the patients who were orthodontically treated as having a thyroid or pituitary dysfunction. However, his diagnosis of thyroid dysfunction was based solely on basal metabolic rate readings. Since the range for normality in this test varies almost from one institution to the next and since no other objective, pertinent criterion, of thyroid dysfunction was used, this viewpoint has been held to be still unproved by other investigators and by clinicians.

In a review of the etiological factors in orthodontic root resorptions, Hemley concluded through eclectic logic that if teeth were moved by tipping, rather than bodily, there would be no further fear of root resorption as a consequence of orthodontic therapy.[13] Idiopathic resorption which occurred independent of orthodontic movement was due, he said, to malposed teeth which became laterally (bodily) displaced as a result of traumatogenic occlusal forces. To test this view, Hemley instituted orthodontic therapy on 195 patients, using gentle intermittent tipping forces and avoiding bodily movements of the teeth.[14] He reported that only 21.5 per cent of the 195 persons treated showed evidence of root resorptions. Only 3.5 per cent (172) or 4,959 teeth subjected to this form of orthodontic therapy showed evidence of root resorptions. He was convinced that the incidence of root resorption could be reduced by these means (tipping movements) to the extent that it need not be regarded as a hazard to orthodontic treatment.

In this regard, the only conclusion that can be made from the findings in this study is that it behooves the orthodontist to make a complete roentgenographic survey of his prospective patient before treatment. This would lead to a wiser choice of patients, eliminating those who show a high degree of odontoclastic activity before treatment and in whom the prognosis might be unfavorable. Early detection of severe root resorptions also might lead to the discovery of local and/or systemic factors superposed upon a predisposition to periapical resorption. It would be interesting to correlate the resorptive potential of the tooth root as herein described with the amount of resorptions

seen in the alveolar process in order to discover whether the resorption of cementum dentin and of bone bear any relation to each other. Such studies are in progress.

SUMMARY AND CONCLUSIONS

This investigation was designed to study the frequency and the degree of idiopathic periapical resorption in human permanent teeth, as revealed by routine, full-mouth roentgenograms. It was found that:

1. One hundred per cent of the *persons* examined showed some evidence of periapical resorption in one or more of the permanent tooth roots.

2. Eighty-six and four-tenths per cent of the *teeth* examined showed evidence of some resorption. Only 1.6 per cent of the teeth revealed (roentgenographically) no evidence of resorption. The remaining 12 per cent of the teeth were questionable.

3. An average of sixteen teeth per person showed some evidence of periapical resorption. There were no striking differences between males and females.

4. There were no significant differences between the number of maxillary and mandibular teeth affected. The resorptive pattern was strongly bilateral.

5. The order of susceptibility of teeth to resorptions in this study was consistent with other studies.

6. In only 5 per cent of the teeth was there any evidence as to the cause of the resorption (periapical infection and root canal therapy). In 81.2 per cent of the teeth, no reasons for the resorption were obvious (idiopathic resorptions).

7. The distribution of idiopathic resorptions in unselected cases was as follows:

(a). 71 per cent were mild, the apex of the root being only slightly blunted.

(b). 9 per cent showed moderate amounts of resorption (root resorbed for at least 2 mm. to 4 mm.).

(c). 0.30 per cent were severely resorbed (root resorbed 4 mm. to one-fourth root length).

(d). 0.11 per cent showed very severe resorption (more than one-fourth of the root resorbed).

8. There appeared to be a significant increase in the frequency of the more severe degrees of resorptions with age.

9. The intraoral roentgenograms of eighty-one orthodontically treated patients also were assessed. It was found that the number of teeth resorbed, and particularly the severity of the resorptions, were markedly increased by orthodontic procedures.

10. In a sample of seventy-six cases treated orthodontically, a good prediction as to the degree of root resorption after orthodontic treatment could be

made by analysis of the roentgenograms taken before treatment. This prediction was more accurate when individual teeth were assessed before and after treatment than when the case was assessed as a whole.

11. It is concluded that a definite resorptive potential is resident in the permanent (as well as the primary) teeth of all persons. This resorptive potential varies in different persons and also in different teeth of the same person. The resorptive potential was found to be inherently high in approximately 10 per cent of this sample. This figure correlates well with the approximately 14 per cent of teeth that showed severe degrees of resorptions after orthodontic treatment.

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Editorial

Out of the Mouths of Dental Patients

THE orthodontist and the general dental practitioner in a period of economic adjustment can obtain much useful and interesting information by taking a long-term look into the mouths of their patients. *A Survey of Needs for Dental Care* was published recently in pamphlet form by the Bureau of Economic Research and Statistics of the American Dental Association. This survey was begun in 1952 and is similar to one conducted in 1940. It is concerned with dental patients—persons who actually come to the dentist for treatment—and does not represent the dental needs of the population as a whole.

Of the 25,000 dentists invited to participate in the survey, some 4,000 responded and returned questionnaires on approximately 40,000 patients who visited their offices on a given day.

There were fourteen female patients for every ten male patients who came to the dentist for treatment. "In general," the survey states, "it may be said that occupations which are highest on the scale of education, social standing and income are best represented among dental patients." However, further analysis of the findings of the survey discloses that the foregoing does not characterize dental patients in general. Of those surveyed, 73 per cent had visited their dentists within a period of one year, as against only 50 per cent of the general population who had done so. This would seem to indicate that going to the dentist at periodic intervals can become a habit and that the dentist who has a good follow-up system can actually habituate his patients to maintain their teeth in a healthy condition by frequent dental inspection and care. In a competitive economy, when the consumer finds himself with a decreasing number of dollars to spend, he purchases first those items which he has been taught by advertisers to look upon as necessities. Dental needs are usually postponed.

Both boys and girls show a steep rise in the number of teeth needing fillings between the ages of 10 and 18 years, when the apex of dental decay is reached, with boys averaging almost six carious teeth and girls around five carious teeth. While children about to enter grade school and young men and women entering college are, as a rule, subjected to dental examination and are required, or at least advised, to have all dental work completed, the high school students appear to be overlooked. Thus, young people in this

group, who have their newly acquired permanent dentitions and who are at an age of highest caries susceptibility, are allowed to go on and lose teeth at random. It is not at all surprising, therefore, that the young men entering military service are found to suffer from a high incidence of dental caries and widespread diseases of the oral tissues. Campaigns for children's dental care should be extended to include high school students as well as those in the younger age groups.

Dental caries neglect led all other causes as the reason for extraction in women up to age 40 and in men up to age 35 years. A total of 26.9 per cent of this group needed at least one complete denture. These facts should be brought to public attention. Dentistry should do much more to inform the public that regular dental care, rather than the use of certain dentifrices as advertised in public information media, is the only method of preventing loss of teeth.

It is interesting to note that the general practitioners participating in the survey found one out of every four children in the 10- to 14-year age group to need correction of malocclusion. The malocclusions found were obviously of the more severe type that could be recognized easily without special training in orthodontics. It is generally accepted that from 35 to 50 per cent of the children in the population as a whole require some orthodontic care. A controlled study of orthodontics needs on a nationwide sampling would prove of value to public health and to orthodontics.

The widespread neglect of dental care among Negroes was emphasized by the fact that "... the need for extractions was much higher among Negroes and the number of permanent teeth missing was substantially higher" among Negroes than in members of the white population who visited a dentist.

Since all male patients showed more teeth needing extractions and more missing permanent teeth than female patients, and also since a larger percentage of the men than of the women required full dentures, the survey concluded that men are more likely to neglect their teeth. This should indicate to the dentist also that the esthetic value of dental care is an important factor in bringing patients to his office.

That people who can afford to pay for dental care usually get it is shown by the fact that "the number of extractions required because of decay showed a marked variation according to the income of the patient." The lowest income group was found to need about five times as many extractions as those in the top income brackets. However, economic status appears to be "not as great an obstacle to timely dental care among women as it is among men." Finally, there is the fact that dental patients saw their dentists more frequently in 1952, when employment was at the peak, than in 1940, when wages were lower and unemployment higher.

The problem of "latent demand" for dental service was largely ignored during the war years and in the immediate postwar period of prosperity. Under a peace economy with its consequent economic adjustment, the potential

need for dental care must be translated into an active demand if dentists are to continue to be fully occupied with their professional activities.

In conclusion, it can be said that the survey contains much food for thought for dentistry as a profession in planning dental care on a population basis and, furthermore, that dentistry has an important public health education problem which awaits solution.

J. A. S.

In Memoriam

I. WILLIAM BULL

1895-1954

ON APRIL 2, 1954, the dental profession lost one of its pioneer members in the field of orthodontics in the Southeast—I. William Bull.

Dr. Bull was born in Gorin, Missouri, July 6, 1895, the son of Ida and Bert Bull. He attended William Jewell College, Liberty, Missouri, and received his degree in dentistry at Vanderbilt University, Nashville, Tennessee, in 1918. After serving in the United States Army in World War I, he took his graduate work in orthodontics at the Dewey School of Orthodontia, New York City, opening his office in Jacksonville, Florida, in 1920, where he practiced until his sudden death in his office.

Dr. Bull was the first orthodontist in Jacksonville and the second in the State of Florida. He was meticulous in his work and was called a perfectionist by his colleagues. One of his original methods of the technique was his use of the "wire twister."

His professional membership included the American Association of Orthodontists, Southern Society of Orthodontists, Florida State Dental Association, Northeast District Dental Association, Jacksonville Dental Society, and the Florida Study Group. He received an honorary fellowship for twenty-five years' service from the Florida State Dental Association.

He was a member of the Phi Omega Dental Fraternity, Kappa Sigma Social Fraternity, Florida Yacht Club, and the Timuquana Country Club.

He was an enthusiastic golfer, winning the Timuquana Club Cup and the Fuller Trophy in 1932. Known affectionately to his friends as "Johnny," he was greatly respected, both as a man and for his professional ability.

Dr. Bull was married to Emaline Greene in Nashville, Tennessee, in 1921. He leaves his widow; a daughter, Mrs. Maxwell King Morris, Corpus Christi, Texas; and a son, Thomas Albert Bull, a second-year student at the Medical College of Virginia, Richmond, Virginia.

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The Topology of the Human Premaxillary Bone: By Charles R. Noback and Melvin L. Moss. Reprinted (with deletions) from *Am. J. Phys. Anthropol.* **2**: 181-187, June, 1953.

Two schools exist concerning the fate of the premaxillary bone in man. One view holds that the maxillary bone overgrows the premaxillary bone ectofacially, so that, except for the anterior nasal spine, the definitive premaxillary bone is not present on the superficial aspect of facial skeleton (Keith, '48). The contrary view claims that the maxillary bone fuses with the premaxillary bone ectofacially at the incisive suture and does not overgrow the premaxillary bone (Inouye, '12; Chase, '42). As a result the premaxillary bone is represented in the adult in a topological position similar to its fetal location.

If the absence of the premaxillary bone on the human face is a "specific human character" (Wood Jones, '47), the resolution of these conflicting views has special significance to physical anthropologists and students of human phylogeny.

This paper is concerned with an evaluation of these views. The conclusion is reached that in man: (1) the premaxillary bone and maxillary bone fuse at the incisive suture and (2) the maxillary bone does not overgrow the premaxillary bone.

To analyze this problem, it is essential that observations be made on embryos from 18 to 40 mm CR length (7-9 fetal weeks of age). The ossification centers of the premaxillary bone and maxillary bone appear in embryos of 15 to 35 mm CR length and the loss of the incisive suture occurs in embryos of less than 40 mm CR length (Augier, '31; Noback and Robertson, '51).

The bilateral maxillary processes are dorsal projections of the first branchial arch. By growing anteriorly and fusing with the globular portions of the median nasal processes they supply the anlage of the upper jaw and together with the inferiorly situated mandibular processes they will form the external oral aperture. All of the approximative growth and fusion of these embryonic processes occurs before the appearance of the membrane bones in this region. The relative contributions of the maxillary process and the median nasal process are an accomplished datum before osseous differentiation commences. The area of extent of the premaxillary bone is greater than that of the median nasal process (Inouye, '12). The portion of this bone that does not ossify in the median nasal process differentiates in the embryonic maxillary process. Hence the premaxillary bone ossifies in the unified connective tissue mass that results from the intimate fusion of the maxillary process with the median nasal process. This concept is accepted by all workers in the field, including Frazer ('40) and Keith ('48), who, however, confuse the matter, by inferring that the labial (external) lamina of the premaxillary bone is derived only from the maxillary process.

A distinction should be made between the contributions of the embryonic membranous processes to the development of the adult lip and to development of the bones of the region. Comparative anatomical studies by Boyd ('32)

demonstrate that animals with definitive incisive sutures have many degrees of completely uncorrelated stages of the contributions of the medial nasal process to the formation of the upper lip and to the differentiation of the premaxillary and maxillary bones.

The original investigations of Inouye ('12), Peter ('13), Felber ('17), and Chase ('42), are among the few papers in the literature concerned with this problem that present detailed observations made on 6 to 9 fetal week old human embryos. Their meticulous and critical studies are based on serial sections and wax reconstructions. These authors find no evidence of osseous overgrowth of the premaxillary bone by the maxillary bone. They insist that a process of fusion of the labial (external) lamina of the premaxillary bone with the analogous lamina of the maxillary bone occurs at about the 9th week and that thereafter evidence of this development process is irretrievably lost.

Our data support these views. Both the premaxillary bone and maxillary bone are present in each series of 15 embryos (bones stained with alizarin red) from 24 to 39 mm CR length (Noback and Robertson, '51). A 24 mm CR embryo has an incisive suture. In a 29 mm CR embryo, the right incisive suture is only present superiorly while the left suture is so narrow that the two bones are in contact. Evidences that the suture is being obliterated ectofacially are found in the other 13 embryos. Included are (1) the persistence of the upper third of the suture and (2) the presence of perforations in the lower two-thirds of the suture. The perforations, seldom found in older embryos, are interpreted as remnants of the suture. These morphological features may be found either unilaterally or bilaterally. No evidence is noted to suggest that the medial ectofacial border of the maxillary bone is migrating medially over the premaxillary bone. Likewise an examination of 99 fetuses from 40 mm CR to 175 mm CR (up to 19 weeks of age) yields no evidence of the medial ectofacial overgrowth by the maxillary bone.

HISTORY OF THE PROBLEM

The European literature and textbooks (Fischel, '29; DeBeer, '37; Brandt, '49) demonstrate that the premaxillary bone and the maxillary bone fuse ectofacially at the incisive suture. In addition they find no support for the overgrowth of the premaxillary bone by the maxillary bone. Chase ('42), in this country conclusively substantiates the fusion concept and rejects the overgrowth hypothesis. This paper escaped serious notice probably because of its publication in a dental journal.

In contrast, some of the British literature and textbooks confuse the picture by accepting the maxillary overgrowth concept without presenting evidence obtained from 6-9 week old human fetuses

Two schools exist concerning the fate of the premaxillary bone in man. One view holds that the maxillary bone overgrows the ectofacial aspect of the premaxillary bone while the contrary view claims that the maxillary bone and premaxillary bone fuse ectofacially at the incisive suture.

The premaxillary bone and maxillary bone of man fuse at the ectofacial surface. This concept is supported by direct observations made on 6 to 9 week old human fetuses—the age during which the suture is obliterated. Data in the literature and original observations are presented.

The maxillary bone does not overgrow the ectofacial surface of the premaxillary bone. The overgrowth thesis is based on observations of fetuses over 9 weeks old—ages after which the incisive suture has been obliterated. No direct observations demonstrating the overgrowth have been presented in the literature.

News and Notes

Principles of Ethics of The American Association of Orthodontists

THE JOURNAL is glad to print the *Principles of Ethics* of the American Association of Orthodontists adopted by the Board of Directors and the membership of the A.A.O., May 20, 1954, at the annual convention in Chicago. The fine work of those who have cooperated to provide these *Principles of Ethics* is now evidenced in a practical way.

While the Association had previously adopted the American Dental Association's *Principles of Ethics* and these principles will still be used as a basis, there has been much thought during the past few years about having an A.A.O. code of ethics, because of the many problems facing orthodontists which the general practitioner does not have.

During Dr. Brooks Bell's term as president of the A.A.O., he appointed Drs. W. R. Alstadt, Little Rock, Arkansas; Paul Hoffman, Washington, D. C.; Cecil Muller, Omaha, Nebraska; Arnold Stoller, Seattle, Washington; and William Weichselbaum, Savannah, Georgia, as a Code of Ethics Committee with the assignment to study the problems carefully and to work out the code of ethics for the orthodontists. This committee, with William Alstadt as Chairman, in consultation with many leaders in orthodontics all over the country, worked hard and faithfully. The Board of Directors reviewed their recommendations, made a few minor alterations, and directed the Constitution and By-Laws Committee to prepare suitable changes in the Constitution and By-Laws.

The *Principles of Ethics*, as adopted by the Board and the membership, is hereby printed in full for the benefit of all who are interested in this subject:

PRINCIPLES OF ETHICS OF THE AMERICAN ASSOCIATION OF ORTHODONTISTS

The practice of dentistry first achieved the stature of a profession in the United States where through the heritage bestowed by the efforts of many generations of dentists, it acquired the three unfailing characteristics of a profession: education beyond the usual level, the primary duty of service to the public and the right to self-government.

The maintenance and enrichment of this heritage of professional status place on everyone who practices dentistry an obligation which should be willingly accepted and willingly fulfilled. This obligation cannot be reduced to a changeless series of urgings and prohibitions for, while the basic obligation is constant, its fulfillment may vary with the changing needs of a society composed of the human beings that a profession is dedicated to serve. The spirit and not the letter of the obligation, therefore, must be the guide of conduct for the professional man. In its essence, this obligation has been summarized for all time and for all men in the golden rule which asks only that "whatsoever you would that men should do to you, do ye even so to them."

THE DENTIST AS A MEMBER OF A PROFESSION

Education Beyond the Usual Level.—The right of a dentist to professional status rests in the knowledge, skill and experience with which he serves his patients and society.

Every dentist has the obligation of keeping his knowledge and skill freshened by continuing education through all of his professional life.

Service to the Public.—The dentist has a right to win for himself those things which give him and his family the ability to take their proper place in the community which he serves, but there is no alternative for the professional man in that he must place first his service to the public rather than gain to himself.

Government of a Profession.—Every profession receives from society the right to regulate itself, to determine and judge its own members. Such regulation is achieved largely through the influence of the professional societies, and every dentist has the dual obligation of making himself a part of a professional society and of observing its rules of ethics.

INTRODUCTION.—Since all orthodontists, by reason of their basic education and licensure, have the same fundamental ethical responsibilities as other members of the dental profession, the American Association of Orthodontists has adopted as its general code of ethics the "Principles of Ethics of the American Dental Association."

GENERAL PRINCIPLES OF ETHICS.—The following are the principles of ethics which shall apply, in spirit and letter, to the members of the American Association of Orthodontists:

The Orthodontist's Duties to the Public

The orthodontist's primary duty of serving the public is discharged by giving the highest type of service of which he is capable and by avoiding any conduct which leads to a lowering of esteem of the profession of which he is a member.

Section 1. Leadership.—The orthodontist has the obligation of providing freely of his skills, knowledge and experience to society in those fields in which his qualifications entitle him to speak with professional competence. The orthodontist should be a leader in his community, especially in all efforts leading to the improvement of the dental health of the public.

Section 2. Emergency Service.—The orthodontist has an obligation when consulted in an emergency by the patient of another orthodontist to attend to the conditions leading to the emergency and to refer the patient to his regular orthodontist who should be informed of the conditions found and treated.

Section 3. Use of Auxiliary Personnel.—The orthodontist has an obligation to protect the health of his patient by not delegating to a person less qualified any service or operation which requires the professional competence of an orthodontist. The orthodontist has a further obligation of supervising the work of all auxiliary personnel in the interests of rendering the best service to the patient.

Section 4. Consultation.—The orthodontist has the obligation of seeking consultation whenever the welfare of the patient will be safeguarded or advanced by having recourse to those who have special skills, knowledge and experience. A consultant will hold the details of a consultation in confidence and will not assume responsibility for treatment without the consent of the attending orthodontist. Whenever a patient desires consultation with another orthodontist the consultant should first discuss his opinion with the orthodontist treating the patient before giving his opinion to the patient.

Section 5. Unjust Criticism.—The orthodontist has the obligation of not referring disparagingly to the services of another orthodontist in the presence of a patient. Criticism of any of the services or lack of services rendered may be unjust because of the lack of knowledge of the conditions under which the services or directions were afforded. However, the welfare of the patient is paramount to every other consideration, and should be conserved to the utmost. If there is indisputable evidence that a patient is suffering from previous faulty treatment or diagnosis, correct treatment should be instituted, doing it *with as little comment as possible*, and in such a manner as to avoid reflection on the patient's previous orthodontist and the profession.

Section 6. Rebates, Split Fees, and Commissions.—The orthodontist has the obligation of disclosing to his patients all of the elements involved in the establishment of fee and he may not, therefore, give or accept rebates, split fees or commissions from any source associated with the service rendered to the patient.

Section 7. Secret Therapeutic Agents.—The orthodontist has an obligation not to dispense or promote the use of drugs or other agents whose composition is secret. He also has the obligation not to dispense or prescribe except for limited experimental purposes any therapeutic agent, the value of which is not supported by scientific evidence.

Section 8. Patents and Copyrights.—The orthodontist has the obligation of making the fruits of his discoveries and labors available to all when they are useful in safeguarding or promoting the health of the public. Patents or copyrights may be obtained by an orthodontist only when their primary purpose is the protection of the public and the profession.

Section 9. Advertising.—The orthodontist has the obligation of advancing his reputation for fidelity, judgment and skill solely through his professional services to his patients and to society. The use of advertising in any form to solicit patients is inconsistent with this obligation because it reflects adversely on the orthodontist who employs it and lowers public esteem of the specialty of orthodontics.

Section 10. Cards and Letterheads.—An orthodontist may properly utilize professional cards, announcement cards, recall notices to patients of recent record and letterheads when the style and text are consistent with the dignity of the profession and with the custom of other members of the dental profession in the community.

Section 11. Office Door Lettering and Signs.—An orthodontist may properly utilize office door lettering and signs provided that their style and text are consistent with the dignity of the profession and with the custom of other members of the dental profession in the community.

Section 12. Announcements.—An orthodontist may properly send announcement cards when beginning practice, or when there is a change of location, or an alteration of the character of practice. Such announcements may be sent only to other orthodontists, dentists, members of other health professions or to patients of record. The style and text of such announcements shall be consistent with the dignity of the profession and with the custom of other members of the dental profession in the community.

Section 13. Use of Professional Titles and Degrees.—An orthodontist may use the usual titles or degrees (Doctor, Dentist, D.D.S. or D.M.D.) in connection with his name on cards, letterheads, office signs and announcements, but he may not so use his title or degree in connection with the promotion of any drug, agent, instrument, or appliance. Good taste should be exercised regarding the usage of "Honorary Degrees" so that reflection upon the individual orthodontist and the profession may be avoided.

Section 14. Use of Terms "Clinic" or "Group Practice."—An orthodontist may participate in a regularly established clinic or group service, but he may not apply the term "clinic" or similar designation to such practice when the use of such term may mislead the public directly or indirectly.

Section 15. Limitation of Practice.—An orthodontist may indicate the limitation of his practice on his card, letterhead, announcements and office sign.

Section 16. Directories.—An orthodontist may permit the listing of his name in a directory provided that all dentists in similar circumstances have access to a similar listing and provided that such listing is consistent in style and text with the custom of the dentists of the community.

Section 17. Education of the Public.—An orthodontist may properly participate in a program for the education of the public on matters pertaining to dentistry provided such a program is in keeping with the dignity of the profession and has the approval of the dentists of a community or state acting through the appropriate agency of the dental society.

Section 18. Patients Under Observation.—When the orthodontist assumes the obligation of placing a patient under orthodontic observation, he shall cooperate closely with the family dentist in such matters as periodic dental examination and the general maintenance of good oral health.

Section 19. Transfer of Orthodontic Patients.—When circumstances necessitate the transfer of an orthodontic patient, the following obligations shall be fulfilled in the best interests of the dental health of the patient:

(A) The parents shall be informed of all conditions necessary to effect a satisfactory transfer but no commitments shall be made regarding (a) the length of time needed by the new orthodontist to complete his treatment of the case; (b) the continuance of treatment with the use of the same appliances; (c) the fee to be charged by the practitioner to whom the case is transferred.

(B) When the judgment of the orthodontist dictates a change in the appliances of a transfer patient, such change shall be effected so as not to endanger the confidence of the patient in his course of treatment. It is unprofessional for an orthodontist to indicate in any way that any remedy, technique, method of treatment, or instrument is exclusive to himself, or to a group of which he is a member.

(C) When the judgment of the orthodontist requires a revision of the diagnoses and treatment previously given a transfer patient, the necessary adjustments should be made, but in no case should the orthodontist comment disparagingly since he cannot be wholly familiar with the circumstances which dictated the previous diagnosis and treatment.

(D) A free exchange of correspondence and information between orthodontists is advisable in all cases of transfer so that the dental health of the patient may continually be safeguarded.

Section 20. Post-treatment Responsibilities.—The orthodontist has an obligation to fully inform all patients and their parents regarding normal and abnormal post-treatment developments so that the benefits of orthodontic treatment may not be jeopardized.

Section 21. Official "Principles of Ethics."—This statement will constitute the "Principles of Ethics" of the American Association of Orthodontists. Its constituent and component societies are urged to adopt additional provisions or interpretations not in conflict with these "Principles of Ethics" which would enable them to serve more faithfully the traditions, customs and desires of the members of these societies.

Section 22. Judical Procedures.—Questions involving ethics should be resolved within the "Principles of Ethics," by the appropriate agency within the constituent orthodontic society. If a satisfactory decision cannot be reached at the constituent level the provisions of Chapter V, Section 10 of the by-laws may be invoked.

Section 23. Pledge.—Each member of this Association shall at all times display by his deeds and by his statements, loyalty and allegiance to this Association and to its aims, its interests, its ideals and its standards. Any person violating this provision shall be subject to discipline by this Association.

1955 Prize Essay Contest, American Association of Orthodontists

Eligibility.—Any member of the American Association of Orthodontists and any person affiliated with a recognized institution in the field of dentistry as a teacher, researcher, undergraduate, or graduate student shall be eligible to enter the competition.

Character of Essay.—Each essay submitted must represent an original investigation and contain some new significant material of value to the art of science of orthodontics.

Prize.—A cash prize of $500.00 is offered for the essay judged to be the winner. The committee, however, reserves the right to omit the award if, in its judgment, none of the entries is considered to be worthy. Honorable mention will be awarded to those authors taking second and third places. The first three papers will become the property of the American Association of Orthodontists and will be published. All other essays will be returned.

Specifications.—All essays must be in English, typewritten on 8½ by 11 inch white paper, double spaced with at least 1 inch margins. Each sheet must be numbered and bound or assembled with paper fasteners in a "brief cover" so that they may be handled easily. Three complete copies of each essay, including all illustrations, tables, and bibliography must be submitted. The name and address of the author must not appear in the essay. For purpose of identification, the author's name, together with a brief biographical sketch which sets forth his or her dental and/or orthodontic training, present activity, and status (practitioner, teacher, student, research worker, etc.) should be typed on a seperate sheet of paper and enclosed in a sealed envelope. The envelope should carry the title of the essay.

Presentation.—The author of the winning essay will be invited to present it at the meeting of the American Association of Orthodontists to be held at the Fairmont Hotel, San Francisco, California, the week of May 9, 1955.

Judges.—The entries will be judged by the Research Committee of the American Association of Orthodontists.

Final Submission Date.—No essay will be considered for this competition unless received in triplicate at the following address on or before Feb. 15, 1955: Dr. Alton W. Moore, Medical Dental Building, Seattle, Washington.

J. A. Salzmann, Chairman, Research Committee
American Association of Orthodontists
654 Madison Ave.
New York 21, N. Y.

American Association of Orthodontists, 1955 Research Section Meeting

Continuing the policy of recent years, the program will consist of a series of ten-minute research reports which may be presented orally or read by title only. All persons engaged in research are urged to participate in this program which will be held Wednesday afternoon, May 11, 1955, in the Fairmont Hotel, San Francisco, California.

Each participant is asked to prepare a 250-word abstract for publication in the AMERICAN JOURNAL OF ORTHODONTICS. Abstract for publication and the ten-minute oral presentation at the meeting should be carefully prepared to present an adequate description of the import of your investigation.

Forms for use in submitting the title and 250-word abstract of your research will be sent to each dental school orthodontic department and to any individual requesting one. Please send your title and abstract as early as possible, but not later than March 10, 1955, to Dr. Thomas D. Speidel, University of Minnesota, School of Dentistry, Minneapolis 14, Minnesota.

J. A. Salzmann, Chairman
Research Committee
American Association of Orthodontists
654 Madison Ave.
New York 21, N. Y.

The Fabulous Fairmont

(Symbol of the Grace, Charm, and Dignity That Is San Francisco)

In the glamorous period after the Gold Rush and before the earthquake and fire of 1906, it was the custom of the wealthiest San Francisco citizens to build mansions atop Nob Hill, commanding a broad vista of the Golden Gate and San Francisco Bay. This fashion was followed by Senator James D. Fair, one of the famous early San Francisco tycoons,

whose mansion took the form of a great hotel that all the world might enjoy. The opening of the Fairmont was planned for April 1906, but because of the San Francisco disaster, the formal opening was delayed until April 19, 1907.

The handsome Fairmont proudly boasted of a private bathroom in every room. People came from all over the world to see the Fairmont and San Francisco. As the years passed, the Fairmont settled back and became the quiet residence for many of the finest citizens of San Francisco.

The Fairmont Hotel in San Francisco, where the American Association of Orthodontists will hold its next annual meeting in May, 1955.

In 1945, the Fairmont became the property of the Benjamin H. Swig family, and, under their vision and progressive leadership, has become the San Francisco home of royalty, presidents, statesmen, famous personages, and just plain citizens from all over the world. Because Mr. Swig is a perfectionist, the hotel is under constant modernization and is always a pace or two ahead of most American hotels.

The luxurious Venetian Room is the main dining and dancing room of the Fairmont, while three of the most popular cocktail lounges in San Francisco are the sophisticated Cirque Room (for cocktails and dancing), the Cirque Lounge, and the unusual La Ronde featuring a rotating merry-go-round. The Papagayo Room offers authentic Mexican food in south-of-the-border atmosphere. One of the nation's most original dining rooms, the Tonga Room (built around a pool with the orchestra on a floating pavillion) specializes in exotic Chinese dishes. The Fairmont also has exceptional facilities for banquets and conventions.

American Board of Orthodontics

The next meeting of The American Board of Orthodontics will be held at the Fairmont Hotel in San Francisco, California, May 3 through May 7, 1955. Orthodontists who desire to be certified by the Board may obtain application blanks from the secretary, Dr. C. Edward Martinek, 661 Fisher Bldg., Detroit 2, Michigan.

Applications for acceptance at the San Francisco meeting, leading to stipulation of examination requirement for the following year, must be filed before March 1, 1955. To be eligible, an applicant must have been an active member of the American Association of Orthodontists for at least three years.

Dr. Charles R. Baker Receives Orthodontics' Highest Award*

Orthodontics' highest award was conferred on Dr. Charles R. Baker of Evanston at the fiftieth annual meeting of the American Association of Orthodontists on May 17 at the Palmer House in Chicago.

The honor is in recognition of Doctor Baker's many contributions to orthodontics, and is known as the Albert H. Ketcham Memorial Award. It is presented annually to the orthodontist whose devotion and service to the profession are of exceptional merit. Conferring the award has not been limited, however, to orthodontists; it has also been granted to other distinguished men in fields allied to dentistry. In 1949, for example, it was presented to Dr. William K. Gregory, anthropologist, of the American Museum of Natural History.

Doctor Baker's interest in dentistry dates from the beginning of the century. He graduated from the Northwestern University Dental School in 1903, and was appointed instructor in orthodontics at Northwestern in 1904. Ultimately he became professor and head of the department, during which time he established the graduate course in orthodontics at Northwestern in 1923. He practiced general dentistry in Riverdale and Chicago before moving to Evanston in 1908. In 1909 he limited his services to orthodontics, and still is in active practice in his specialty.

Doctor Baker's activities have covered the entire field of orthodontics and have extended into the general practice of dentistry as well. He has written more than 60 papers and has been a member of more than 200 committees. At one time or another he has been president of the Chicago Dental Society, the American Association of Orthodontists, American Board of Orthodontics, Chicago Association of Orthodontists, Evanston Association of Dentists, and of several other dental organizations.

Doctor Baker has also served various dental organizations as vice-president, secretary-treasurer, director, delegate, committee chairman, editor, and librarian. He has been a founder and charter member of several local dental groups. For more than 20 years he acted as chairman of the children's dental clinic sponsored by the Junior League of Evanston. In addition, he has given many general clinics, radio talks, and lectures, and has always been first to lend a helping hand to the younger men during their early years of practice.

In addition to this new honor, Doctor Baker has received the Award of Merit from the Alumni Association of Northwestern University. He is a member of Omicron Kappa Upsilon scholastic dental fraternity, of Delta Sigma Delta fraternity, and is a Fellow of the American College of Dentists. All Chicago dental organizations join in congratulating Doctor Baker in this recognition by the American Association of Orthodontists of his many services to dentistry.

Middle Atlantic Society of Orthodontists

The fall meeting of the Middle Atlantic Society of Orthodontists will be held on Oct. 3, 4, and 5, 1954, at the Chalfonte-Haddon Hall, Atlantic City, New Jersey.

Southwestern Society of Orthodontists

The Southwestern Society of Orthodontists will hold its next annual meeting in Oklahoma City, Oklahoma, Oct. 17, 18, 19, and 20, 1954, at the Skirvin Hotel.

*From The Fortnightly Review of the Chicago Dental Society, May 15, 1954.

Temple University

Temple University of Philadelphia, Pennsylvania, has announced a two-week course in orthodontics for practicing orthodontists under R. H. W. Strang, D.D.S., Jan. 23, 1955, to Feb. 5, 1955.

Notes of Interest

Dr. Milton J. Lande announces his return from military service to the exclusive practice of orthodontics at the Medical Tower, 255 South 17th St., Philadelphia 3, Pennsylvania.

Dr. Leonard J. Seide, 11 West 42nd St., New York City, wishes to announce the opening of a second office for the convenience of his patients, at Riverdale Terrace, 5601 Riverdale Ave. at 256th St., Riverdale 71, New York, practice limited to orthodontics.

OFFICERS OF ORTHODONTIC SOCIETIES

The AMERICAN JOURNAL OF ORTHODONTICS is the official publication of the American Association of Orthodontists and the following component societies. The editorial board of the AMERICAN JOURNAL OF ORTHODONTICS is composed of a representative of each one of the component societies of the American Association of Orthodontists.

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Vice-President, Walter K. Appel - - - - - - - - 4018 Moore Ave., Cheyenne, Wyo.
Secretary-Treasurer, Curtis L. Benight - - - - - - - 1001 Republic Bldg., Denver, Colo.

Southern Society of Orthodontists

President, Leigh C. Fairbank - - - - - - - - 1726 Eye St., N.W., Washington, D. C.
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Southwestern Society of Orthodontists

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